PROFILING DOCTORAL GRADUATES AT STELLENBOSCH UNIVERSITY (FROM 2010-2015): UNDERSTANDING THEIR ROLE IN KNOWLEDGE CREATION AND REGIONAL INNOVATION

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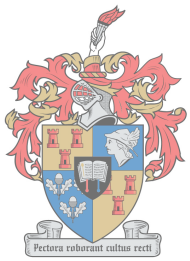

Thesis presented in partial fulfilment of the requirements for the degree Master of Philosophy in Urban and Regional Science in the Faculty of Arts and Social Sciences at Stellenbosch University

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AUTHOR'S DECLARATION

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ABSTRACT

South Africa, as an emerging economy, faces many economic, social and environmental challenges. These challenges are exacerbated by the apartheid legacy of inequality and racial discrimination. Education has been viewed by many scholars as a powerful mechanism to improve inequality and advance South Africa's role in the global knowledge economy – this is especially true for doctoral graduates, the apex-output of the academic project. It is understood that doctoral graduates are highly-skilled producers of knowledge and innovation, as indicated by the National Development Plan's call for 5000 doctoral graduates per year by 2030. Doctoral graduates' impact on knowledge creation and innovation may result in socio-economic benefits for the country. This study aims to articulate the role of doctoral graduates in the creation of new knowledge and its contribution to improving regional innovation potential. The study focuses on doctoral graduates at Stellenbosch University (from 2010-2015). An email-based survey was conducted and used in combination with institutional data to profile these doctoral graduates and understand their knowledge creation and innovation 'footprints' by unpacking their demographic, socio-economic and educational characteristics. In conclusion, recent doctoral graduates are producing. Key findings show that inequality persists in Stellenbosch University's doctoral output since only 6% of all graduates were Black South Africans. It also shows that obtaining a doctoral degree qualification took on average about 20 years after completion of matric. In addition, knowledge creation and regional innovation is a core performance area for graduates contributing 3+ units of research outputs after graduation.

Keywords and phrases:
Doctoral education
Regional innovation
Knowledge creation
Higher education
Knowledge economy
Regional economic development

OPSOMMING

Suid-Afrika, as 'n opkomende ekonomie, staar baie ekonomiese, sosiale en omgewingsprobleme in die gesig. Hierdie uitdagings word vererger deur die apartheid-regering se erfenis van ongelykheid en rassediskriminasie. Onderwys is uitgewys deur baie geleerdes as 'n kragtige meganisme om ongelykheid te verbeter asook om die rol van Suid-Afrika te bevorder in belang van die globale kennis-ekonomie. Dit is veral die geval vir doktorale gegradueerdes, die toppunt-opbrengs van die akademiese projek. Na wat verneem word, is doktorale gegradueerdes hoogs-geskoolde produsente van kennis en bronne van innovasie, soos aangedui deur die die Nasionale Ontwikkelingsplan wat n teiken stel vir 5000 doktorale gegradueerdes per jaar teen 2030. Hul impak op kennis-skepping en innovasie kan lei tot sosio-ekonomiese voordele vir die land. Hierdie studie het ten doel om die rol van doktorale gegradueerdes te ontleed, met fokus op die skepping van nuwe kennis en hul bydrae tot die verbetering van plaaslike potensiaal ten opsigte van innovasie. Die studie fokus op doktorale gegradueerdes aan die Universiteit van Stellenbosch tussen 2010-2015. Die studie gebruik'n e-pos-gebaseerde opname in kombinasie met institusionele data om hierdie doktorale gegradueerdes te profiel met die doel om bydrae ten opsigte van kennis skepping en innovasie te ontleed, deur hul demografiese, sosio-ekonomiese en opvoedkundige eienskappe te analiseer. Sleutelbevindings toon dat ongelykheid voortduur in die Universiteit Stellenbosch se doktorale uitsette aangesien slegs 6% van alle gegradueerdes swart Suid-Afrikaners was. Dit toon ook dat dit gemiddeld sowat 20 jaar neem na matriek om met n doktorale graad te slaag. Kennisskepping en streeksinnovasie is 'n hoof tema vir gegradueerdes wat 3+ eenhede van navorsingsuitsette na gradeplegtigheid bygedra het.

Trefwoorde en frases:
Doktorale onderig
Streeks innovasie
Kennis skepping
Hoër onderwys
Kennis ekonomie
Streeks (plaaslike) ekonomiese ontwikkeling

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CHAPTER 1: SETTING THE SCENE

1.1. INTRODUCTION

It is only quite recently that the role of universities, specifically, as key actors in local and regional economic development, experienced more investigation (Capello, Olechinicka & Gorzelak 2013; Cook & Memedovic 2013; Gray 1999). Regional competitiveness is no longer seen as solely dependent on the traditional factors of production, i.e. capital, land and labour (Capello, Olechinicka & Gorzelak 2013; Cook & Memedovic 2013), with knowledge and innovation now being acknowledged as influential factors for economic growth. Increased globalisation, coupled with the emergence of the 'knowledge economy' and the 'information age', reaffirmed the need for higher education institutions worldwide to reconceptualise their doctoral education models and purposefully set targets for doctoral outputs (Academy of Science South Africa [ASSAF] 2010). Due to the advent of the knowledge society, the focus of doctoral education has shifted from an apprenticeship model, largely focused on training doctoral students and preparing them as the next generation of academics, towards the development of high-level transferable skills (Cloete, Mouton & Sheppard 2015). One of the reasons behind this shift is the notion that knowledge contributes to increased and flexible productivity and human capital development by promoting the creation of new ideas, processes, products and services that yield greater competitive advantages, which functions as a critical catalyst for regional innovation and economic development (Adendorff & Donaldson 2012; Cook & Memedovic 2013; Goldberg 2006). Cementing this need for further investigation and consensus around the value of higher education is the rapid emergence of so-called 'academic capitalism' or the commercialisation of research (outputs) and the rise of the 'entrepreneurial' university, attempting to survive a globalised, competitive world. Universities are considered as the great missing element in regional economic growth and renewal (Gray 1999). In addition, the debate about the benefits of knowledge, innovation and regional economic development continues into the 21st century and forms the central theme of this study.

The potential benefits around knowledge and innovation in regional competitiveness have necessitated the continuous development and renewal of strategies aimed at improving regional innovative clusters in order to boost national competitiveness (Cook & Memedovic 2013). Higher education, specifically doctoral education, provides a unique and important

'commodity' aimed at increasing productivity and regional and/or national competitive advantages. This commodity is a vital element of technological innovation often required by firms, industries as well as governments to advance their objectives and is referred to as the 'learning economy' (Gray 1999).

It is widely recognised that education is a catalyst for the development of high-level skilled professionals, achieving greater equity, and improving productivity, which is especially important for South Africa since its education model used to be structured around the exclusionary racial segregation practices of apartheid. Historically, White students studied at exclusively White universities with more resources, higher quality and standards, while Blacks, Coloured and Indians were restricted to study at selected, exclusively, non-White universities under the Bantu education system. The Extension of the University Act No. 45 (1959) further segregated and oppressed Black students' access to quality universities by restrictive funding policies, and infrastructural allocations to these universities, resulting in poor graduation rates, poor quality teaching and learning and limited capacity for research and innovation (Cloete, Mouton & Sheppard 2015). During the period from 1986-1995, Black, Coloured and Indian graduates only accounted for 7% of all doctoral graduates in South Africa whereas females accounted for 27%, on average (Bunting 1994; Cloete, Mouton & Sheppard 2015).

The South African higher education landscape underwent substantial policy shifts since 1994. For example, The Programme for the Transformation of Higher Education (White Paper 3) envisaged a more equal, inclusive and efficient higher education sector through improved skills development that specifically targeted skill shortages in the labour market and addressed the developmental needs of society which would ultimately contribute to knowledge creation, sharing and innovation (Department of Education 1997). The White Paper's alignment with the macroeconomic policies of reconstruction, transformation and development during the early 1990s formed the foundation for the development of a national research plan and the promotion of private and public funding in order to address the expansion of doctoral education throughout South Africa (Bunting 1994).

The National Plan for Higher Education (2001) delivered the high-level framework for implementing the White Paper 3, which highlighted the restructuring of the higher education

system by setting targets for growth and expansion; it also focused on increasing the participation rate (with regard to the percentage of 20-24 year olds enrolled in higher education) from 5% to 20%, promoting academic development aimed at increasing graduation rates, improving equity (targets) and access, promoting science, engineering and technology (SET) fields while improving the mission statements and programme differentiation of universities. (Ministry of Education 2001). Additionally, the Ministry of Education established a National Working Group in 2008 which aimed at investigating the accessibility and growth potential of higher education institutions across South Africa, the variety of programmes offered at universities, the student-supervisor ratio and/or supervisory-capacity, among others. One key outcome of this investigation was the removal of doctoral programmes from universities that did not have adequate capacity to administer such programmes, however the impact thereof remains to be established.

The South African Government also adopted the National Research and Development Strategy (2002), the Ten Year Innovation Plan (2008) and the National Development Plan (NDP) (NPC 2012), thereby articulating the ideal state of doctoral education in the broader higher education and societal landscapes. The National Research and Development Strategy (2002) outlines goals for a healthy national science and innovation system by promoting a programme of funding fundamental research aimed at developing human capital and creating new knowledge, thus promoting innovation and technological development and commercialisation of research outputs. Similarly, the Ten Year Innovation Plan (2008) states that a five-fold expansion of doctoral education in the SET fields forms part of a coordinated strategy to advance the creation and subsequent sharing of knowledge amongst members of society. Such a strategy would establish South Africa as a competitive role-player in the global knowledge economy, ultimately improving economic growth (Department of Science and Technology 2008). Additionally, the National Development Plan (NDP) also highlights the important role played by doctoral graduates in the national economy and in the research and innovation fields, particularly, and consequently, they set a target of 5000 doctoral graduates per year by 2030 – an ambitious target considering that the current doctoral graduate rate is around 1400 per year (National Planning Commission [NPC] 2011). Currently, the Western Cape has the most traditional universities (3) in SA followed by Gauteng (2). Furthermore, just under 50% of the traditional universities are located in the two provinces containing the major metropolitan cities (City of Cape Town, City of Tshwane and the City of Johannesburg), which suggests that, historically, the spread of universities favoured the urban population.

1.2. PROBLEM STATEMENT

"What is important for growth is integration, not into an economy with a large number of people, but rather into one with a large amount of human capital" (Romer 1990: 98). A major gap in the South African context is a lack of empirical evidence around the underlying issues that influence doctoral education success, efficiencies and the interaction of universities with firms and the public sector (Backhouse 2009). What is lacking from current studies is a micro-level critical analysis at local level of doctoral education and human agency (Blockhouse 2009). The South African government, the Centre for Higher Education and Training (CHET) and the Centre for Research on Evaluation, Science and Technology (CREST) at Stellenbosch University are conducting the bulk of the current studies into doctoral education in South Africa. These studies have highlighted a number of critical factors undermining the potential benefits of doctoral education: the issue of scarce skills and persistent workforce inequality; disparity in geographical location of universities; funding shortages; and inefficiencies related to throughput of students (Cloete, Mouton & Sheppard 2015; Department of Higher Education and Training [DHET] 2015).

Scare skill subjects are producing a small percentage of graduates, i.e. Mathematics (1%), Life and Physical Sciences (5%) and Engineering (5%), which results in critical skill shortages in the labour market and firms to attract international labour (Cloete et al. 2015). This trend negatively affects the employability of graduates and ultimately impedes the regional/national economic development. Similarly, workforce inequality remains a feature of the South African economy to date. The number of skilled workers (managers, professionals, technicians) grew substantially from 1.8 million in 1994 to 3.8 million in 2014. However, proportionally, it should be noted that Black skilled workers had the lowest percentage increase (3%) compared to White skilled workers (19%), Coloured skilled workers (11%) and Indian skilled workers (26%), over the same period, which reinforces existing inequalities in employment and income equity (Statistics SA 2016)[1].

Along similar lines, proximity of universities to urban centres translates into unequal access to higher education between the urban and rural population. This unequal geographical access also

[1] Representative of the non-agriculture formal workforce.

applies to certain programmes offered at select universities due to thematic specialisation, as well as costs variances between rural and urban spaces (living and relocation expenses of students from rural areas). Students from rural areas in SA must travel long distances, or relocate to student residences in order to complete their university qualification. Limited studies have been conducted into the internal mobility of students from rural to urban areas in South Africa, however, children in rural areas have less access to higher education than their urban counterparts, which leads to unequal participation rates, worldwide (UNICEF 2012).

The high cost of tertiary education is a contemporary debate in higher education in South Africa and led to the establishment of the Commission of Higher Education and Training (the so-called Fees Commission). The average tuition for a first year student is R40 000, whereas the average South African household is said the earn R145 000 in 2016. Many students experience financial difficulties during their studies or cannot afford to pay for study fees, emphasised by the recent '#FeesMustFall' student protest action (Karodia, Soni & Soni 2014). One of the reasons behind the high fee cost is increases in the Higher Education Price Index (Department of Justice [DOJ] 2016). The South African government provides financial assistance to students via state subsidies and scholarships. The latter is largely based on support by the National Student Financial Aid Scheme (NSFAS) at undergraduate level and the National Research Foundation (NRF) at postgraduate level. Between 60% and 70% of university students study part-time, which is indicative of the lack of financial assistance for full-time students (Cloete, Mouton & Sheppard 2015). The NRF funds postgraduate studies via its Scarce Skills, Freestanding and Innovation funding calls. In addition, the NRF also funds thousands of research projects aligned to national strategies which further provides student support in the form of grantholder-linked bursaries (NRF 2016).

Inflation for tertiary education grew substantially from 8.1% (2009) to 9.8% (2015) compared to the consumer price index (CPI) which shrunk from 7.1% to 4.6% over the same period, thereby making it increasingly more expensive to study at South African universities since 2009 (KPMG 2016). This shift made it more difficult for students from previous historically disadvantaged communities to pay towards their studies, let alone sustain themselves during their studies. Government expenditure of 12.2% of the total government education expenditure toward South African universities is estimated at +/- 40% of university budgets, thus creating a

huge gap for universities to fill with student fee payments, donations and research-related income (third-stream funding) (KPMG 2016).

Funding provided to universities in the form of subsidies offers insight into the current funding landscape and how government's funding formula may indeed result in continued inequality. The top 50% of subsidy recipients contains all four universities in the Western Cape [CPUT 12th (4%), UCT 10th (5%), UWC 9th (5%) and SU 8th (5%)]. This totals to 19% of the total subsidy paid by the DHET in the 2015/2016 financial year.

Table 2.1: DHET Subsidy payments to South African universities the during the 2015/2016 financial year

University	**Amount R' 000 transferred to University**	**Percentage subsidy received**
Nelson Mandela Metropolitan University (NMMU)	954377.00	4%
Cape Peninsula University of Technology(CPUT)	1059207.00	4%
University of Free State (UFS)	1094929.00	4%
University of Cape Town (UCT)	1225953.00	5%
University of Western Cape (UWC)	1228322.00	5%
University of Stellenbosch (SU)	1282539.00	5%
North West University (NWU)	1450158.00	6%
University of Johannesburg (UJ)	1523839.00	6%
Tshwane University of Technology(TUT)	1555772.00	6%
University of KwaZulu-Natal (UKZN)	1652313.00	6%
University of Pretoria (UP)	1976860.00	8%
Witwatersrand University (WITS)	2437315.00	9%
University of South Africa (UNISA)	2448690.00	9%

In addition to the ability to funding higher education efficiently, effective production of quality graduates at an appropriate rate remains a huge challenge for South Africa. Although the country experienced improvement in the graduation-rate across all post-graduate levels reported from 2000 to 2007, shortcomings are still present in outputs. The graduation-rate increased for both master's (4%) and doctoral (6%) levels (DHET 2016). Over this same period, South Africa only produced 26 doctorates per million of the population, in comparison to the United States of America which produced 201 doctorates per million of the population. These figures strongly support the notion South Africa is underperforming in its doctoral education system and requires expansion to support the demand for high-level skills in South Africa (ASSAF 2010; Cloete, Mouton & Sheppard 2015; NPC 2012; Pedersen 2014).

Throughput of potential doctoral candidates at South Africa's universities are severely hampered by low rates of undergraduate, honours and master's students, all forming part of the higher education pipeline. A cohort study conducted by the DHET (2015) shows that 48% of students graduate from their undergraduate degree, 43% of masters and only 35% of doctoral students graduate at the end of their degree (even with a two-year extension possibilities at all levels). This trend identifies inefficiencies in the South African higher education system that inhibit the graduation of sufficient numbers of students at all levels. Master's students (as the pool of potential doctoral students) have a graduation rate of 22% (on average) whilst doctoral programmes have a much lower graduation rate of 13% (DHET 2016). Stellenbosch University has a relatively higher graduation rate for master's students (27%) and the highest graduation rate for doctoral students (16%) among South African universities (DHET 2016). In South Africa, in light of the low throughput rate (13%), low graduation rate (16%) and high dropout rate, it is evident that expansionary approaches to doctoral education are under pressure, and underlying barriers and negative factors are persisting (Mouton 2011).

1.3. RESEARCH QUESTIONS

The following research questions were explored:

1. What are the demographic, educational and socio-economic profile characteristics of the doctoral graduates at Stellenbosch University (from 2010-2015)?
2. What role do doctoral graduates at Stellenbosch University (from 2010-2015) play in stimulating knowledge creation and regional innovation?

1.4. AIMS AND OBJECTIVES

The study aimed to determine:

1. The demographic, educational and socio-economic profile characteristics of doctoral graduates at Stellenbosch University (from 2010 to 2015)
2. The role that doctoral graduates at Stellenbosch University (from 2010 to 2015) play in stimulating knowledge creation and regional innovation.

This exploratory study does not aim to measure the impact of doctoral graduates, rather to understand their role in shaping society through knowledge creation and regional innovation. These aims were achieved through the following objectives:

1. To determine the demographic, educational and socio-economic characteristics of doctoral graduates at Stellenbosch University from 2010 to 2015.
2. To analyse the role that doctoral graduates at Stellenbosch University (from 2010 to 2015) play in stimulating knowledge creation and regional innovation.

1.5. METHODOLOGY

1.5.1. Epistemology

The study followed a positivistic epistemology because it quantitatively profiled doctoral graduates at Stellenbosch University (from 2010-2015) in order to uncover trends, patterns and relationships while at the same time employed data collection aimed at determining participants' observations on doctoral education, knowledge creation and regional innovation (Mouton 2001). This empirical study also followed a transnational epistemology since it analysed doctoral education from a global perspective, therefore, implying that endogenous and exogenous factors which are interconnected across various countries have an impact on doctoral education at Stellenbosch University.

The participants of the study consisted of doctoral graduates at Stellenbosch University between 2010 and 2015. During this period, Stellenbosch University produced 1 290 doctoral graduates: 174 in 2010, 150 in 2011, 240 in 2012, 225 in 2013, 234 in 2014 and 267 in 2015 (Stellenbosch University 2016). The graduates were from all 10 faculties[2] at Stellenbosch University. Institutional data was retrieved from the Institutional Research Office (IRO), which provided data that covered the demographic, educational and socio-economic characteristics of the participants. It is important to note that Stellenbosch University has two graduation ceremonies per year – one in December and another in March. The March graduation reflects the graduates from the previous year.

[2] The military sciences faculty only introduced a doctoral degree qualification in 2013/2014 (Stellenbosch University 2016).

1.5.2. Data collection and analysis

This study relied on two approaches for data collection. Firstly, secondary data was used to profile doctoral graduates at Stellenbosch University gathered from institutional data with the assistance of the Institutional Research Office. An MS Excel spreadsheet with a number of variables was retrieved from Stellenbosch University's IRO (Table 1.2) which required the compilation of a dataset representative of the 1290 doctoral graduates at Stellenbosch University (from 2010-2015). The second approach to data collection was an email-based survey distributed to the entire list of available contact details for doctoral graduates at Stellenbosch University (from 2010-2015). The survey was compiled using the Checkbox® Survey (SUN Surveys) web-based survey software. Since the questions in the survey referred to personal information, ethical clearance was applied for, approved by the Humanities Research Ethics Committee (HREC) (as a low risk study). Once again, data collected via the email-based survey contained personal and sensitive information and was treated with a high concern for confidentiality and anonymity. Thus, data was stored on a password-protected computer and secure access was provided to the principal investigators alone. The Stellenbosch University Alumni Office assisted distribution of the email-based survey but in the end, they could only compile a database with 1022 email addresses.

The email-based survey **(**Appendix A**)** was sent out twice in an attempt to increase the response rate (approximately one month apart) and individual follow up reminder-emails were sent to a number of participants. Contact details for these participants were retrieved by using the graduation list and searching on the web for publicly available contact details. The survey took approximately 10 minutes to complete and participants could save and continue to complete their responses. The questionnaire consisted out of 33 close-ended questions and 10 open-ended questions. A pilot test questionnaire to a small number of respondents was distributed (5) outside the sample prior to final distribution, which allowed for testing of the validity and the consistency of the questions. MS Excel was used to assist in data clean up and then IBM SPSS Statistics© was used to analyse quantitative data. The survey was sent via email by the Alumni Office to 1022 potential participants of whom 196 (9%) responded. The survey completion rate (41%) was assisted by resending reminders to the mailing list of 1022 doctoral graduates Qualitative responses were analysed by manual coding, using the Grounded Theory and/or inductive analysis approach (Graziano & Raulin 2014). Themes were uncovered and quantified to uncover some underlying trends in the responses and direct quotations were used to support the findings.

Chapter 1 provides the problem statement of the study as well as the methodology, epistemology, data collection and analysis. Chapter 2 unpacks the themes and theoretical concepts cited by literature, which is central to this study. Chapter 3 overviews the results from data analysis and leads to a discussion on the trends and issues highlighted, while Section 4 provides the limitations for this study, recommendations for future studies, policy implications and the conclusions.

Table 1.3: Data Collection Variables

Variables	**Institutional data**	**Survey data**
Demographic	Race	Race
	Gender	Gender
	Age	Age
	Nationality	Nationality
	Home language	Home language
Education	Faculty graduations	-
	Departments	
	-	Title of dissertations
	Degree information	
		Educational history
		Motivations (Push and Pull factors)
Socio-Economic	Employment details	Employment details
		Income category
		Perception on income
		Household size
	Funding sources (doctoral studies)	Funding sources (doctoral studies)
Knowledge creation and regional innovation		Publications
		Innovation products

		Relationship between work and studies
		Aspects of work enjoyable (enablers)
		Aspects of work least enjoyable (barriers)
		Perceptions on knowledge creation and regional innovation

1.5.3. Study area

In 1866, the Stellenbosch Gymnasium in the town of Stellenbosch was established. A decade later, the Arts Department was founded. This department was founded with 120 scholars supervised by two professors in mathematics, natural sciences and classical and English literature. Infrastructure development occurred in order to provide space for more students and staff around 1879; the Victoria College emerged in 1887 (Stellenbosch 2016). The period up to 1900 saw the Victoria College flourish. The college then included a physics laboratory, a library and buildings for education and science teaching. In 1904, this expansion led to the appointment of the research chairs in botany, zoology, applied mathematics and history. The first professor of education was appointed in 1911 (Stellenbosch University 2016).

The Government of the Union of South Africa brought to law the Stellenbosch University Act No. 4 of 1916 which resulted in the University of Stellenbosch being an official university (Stellenbosch University 2016). J.H. Marais, a local benefactor, contributed £100 000 towards the restructuring and renovation of the old Victoria College to what is currently known as the University of Stellenbosch. By 1917, the Victoria College had 40 lecturers and a student body of just over 500 (Stellenbosch University 2016). Since then, the university has expanded drastically to include ten faculties (Agricultural Science, Economic and Management Science, Medical and Health Sciences, Engineering, Arts and Social Sciences, Education, Science, Theology, Law and Military Sciences). These faculties are spread over three campuses, namely: the West Coast area (Military Sciences); Bellville area (Medicine and Health Science, the University of Stellenbosch Business School and the School of Public Leadership); and the main campus in the Stellenbosch town centre and surrounds (Stellenbosch University 2016).

Stellenbosch University is one of the top universities in South Africa and Africa (Stellenbosch University 2016). Between 2006 and 2015, growth was reported in the total number of undergraduate to postgraduate students to the total student body. In 2015, there were 63% undergraduate students and 33% postgraduate students (Stellenbosch University 2016). The total student body increased from 22 569 in 2006 to 30 150 in 2015. The Faculties of Economic and Management Sciences (8129), Arts and Social Sciences (5238) and Medicine and Health Sciences (4328) had the most number of students enrolled in 2015. Stellenbosch University offers doctoral programmes across all ten faculties. The African Doctoral Academy (ADA) located at Stellenbosch University opened its doors during the 2009/2010 financial year and it would be useful for the purposes of this study to include the first cohort of doctoral graduates who received some form of training and skills development support. The ADA offers annual courses to doctoral students across the African continent and abroad that aims at skills development and improving the output-rate for doctoral graduates. Stellenbosch University continues to train and graduate a large number of doctoral students.

CHAPTER 2: DOCTORAL EDUCATION – KNOWLEDGE CREATION AND REGIONAL INNOVATION IN LITERATURE

2.1.INTRODUCTION

Doctoral education evolved significantly as the first doctoral degree was conferred almost a century ago (Cloete, Mouton & Sheppard 2015; Gray 1999). Decades later, the intention, role and purpose of doctoral education has changed, and its relevance to society has become the central focus in critical debates around higher education and training. Doctoral education is currently shaped by exogenous (globalisation, and information and communication technology [ICT], the emergence of the knowledge economy) and endogenous (government policies, funding and infrastructure, and the throughput and postgraduate pipeline) factors. This section will unpack some of these factors in an attempt to understand the various paths to doctoral education success as well as the policies, strategies and trends employed to facilitate doctoral education expansion.

2.2.EVOLUTION OF DOCTORAL EDUCATION

There is a degree of uncertainty over how doctoral education evolved – some scholars argue that it was a natural progression from higher education in ancient Egypt and Ethiopia (Blackhouse 2009), while other scholars (Cloete, Sheppard & Cloete 2015; Nerad & Evans 2015) maintain that it was formally developed with the re-conceptualisation of higher education in Germany. Irrespective of these contested views, it is clear that historically, doctoral studies were used in order to formalise 'research' as qualification (Blackhouse 2009; Nerad & Evans 2014). From this perspective, doctoral education evolved and currently operates under two distinct themes. Firstly, doctoral education aims to develop the next generation of researchers who are able to conduct independent research and train to become lecturers and professors. Secondly, doctoral education aims to produce new knowledge while developing critical high-level transferrable skills, which doctoral graduates can utilise in their respective fields, i.e. in their fields and industries. It is useful to unpack the timeline of doctoral education in order to understand how its function of society has evolved. Table 2.1 illustrates how modern doctoral education has changed from Medieval Europe (1200-1535), Reformation Europe (1535-1750), Enlightenment Europe (1750-1865) and the Era of the Research University (1865-present) (Nerad & Evans 2014). The intention of the doctoral education (pedagogy) shifted through these eras as assessment practices also changed and more research areas/fields were studied. The first

three periods were instrumental in the development of the research profession as practiced today. Doctoral education changed with society and evolved as a product of societal changes (e.g. reformation to enlightenment).

Table 2.1 Evolution of doctoral degrees (adapted from, Nerad and Evans 2014)

Period	**Intention of doctoral education during this period**	**Research fields/areas**	**Assessment practices**
Medieval Europe (1200-1535)	Fostering communities of scholars teaching and writing course material	Medicine, Law, Theology	Teacher wrote the thesis and student had to defend or oppose it. Oral examination
Reformation Europe (1535-1750)	Training of clergy (priests)	Theology, Law	Examination took place by a board of academics who had no specialisation
Enlightenment Europe (1750-1865)	Creation of knowledge and training of future academics	Philosophy, Humanities and Natural sciences	Student wrote the thesis and faculty had to oppose it. Examination was in written form.
Era of the Research University (1865-present)	Fostering settings for research and related training	Subject of most research fields/areas including professional schools	Examination was in written and oral form. The student had to write and defend the thesis

The evolution of doctoral education is influenced by the role of universities in society, government interventions and the job market's ability to absorb doctoral graduates. Furthermore, the role of doctoral graduates in the knowledge economy places more emphasis on its benefits to society, which also influences the evolution of doctoral education.

Higher education faces much uncertainty as debates around its function as a public good or private good is bringing into question its role as an autonomous institution which is self-managed, determines its own agenda and priorities, and its function creating knowledge for the

sake of creating knowledge – the 'Humboldtian' University model (Travaille & Hendriks 2010). The underlying and overarching processes employed in the creation of knowledge, not only for the sake of science, but also for the benefit of society, leads to transformation. Travaille and Hendricks (2010) argue that this process entails translating knowledge created by researchers and academics into outputs of innovation by introducing market elements such as publishing in high impact factor journals or registering patents and issuing prototypes. Unlike the Humboldtian model, the 'Original model', often referred to as the 'Traditional model', views the student as an apprentice completing his/her dissertation (Herman 2011). This model has since been adapted to include elements of the traditional model, where students are expected to complete coursework in addition to completing original research. The intention of the doctorate, based on these two models, while originally revolving around training future academic researchers, was updated to include developing professionals in the private sector. In addition, elements of these are included in variations of doctorates: e.g. doctorate by publication (i.e. a compilation of publications in a book format), doctorates by practice-based assessment (i.e. drama or music), industry-doctorates (i.e. Government makes funding available to a firm hosting a doctoral student in cooperation with a University) and fast-track doctorates (i.e. upgrade from Masters to Doctoral studies) (Herman 2011; Cloete, Mouton & Sheppard 2015; Nerad & Evans 2014).

Government interventions, given these issues and obstacles, play a central role in facilitating the implementation of strategies, which ought to contribute significantly towards doctoral education improvement. The European approach to doctoral education coordination, in the form of the Bologna Declaration of 1999, focuses on entry-level requirements as a standardisation mechanism aimed at improving the 'quality of doctoral students' (Baptista 2016). In addition, the declaration also facilitates programmes towards coordinating and facilitating intra-national mobility of students, a framework for standardising the doctoral degree structure between the various partner-countries, a joint credit system, and strengthening quality assurance mechanisms (Cloete, Mouton & Sheppard 2015). The Lisbon Strategy of 2000, on the other hand, mirrors these objectives and provides a framework of interventionist policies, which acknowledges the importance of innovation as a conduit for economic productivity, the benefits of a learning economy and the impact on societal and environmental sustainability and improvement (Baptista 2016).

The job market, together with such governmental policies, directly influences higher education, and therefore requires greater coordination and cooperation among various stakeholders, i.e. firms and civil society. For example, the United States of America (USA) recently experienced a decline in the growth of doctoral enrolments, which appears to be in contrast to the rapid uptake during the 1990's. This decline in enrolment may be attributed to, in part, a lack of vacancies available at universities to absorb doctoral graduates (Nerad & Evans 2014). Japan, another major producer of doctoral graduates, followed a similar path of doctoral education expansion during the 1990's but has also experienced a decline in doctoral graduate enrolments due to lack of opportunities for doctoral graduates. During the 1990's, Japan aimed to graduate 10 000 doctoral candidates per year. In Japan's case, the job market could not absorb all of the graduates and this in turn negatively influenced the value and status placed on doctoral graduates in the country. In 2010, for example, only 50% of Japanese graduates had full-time positions secured by the time they graduated; only 162 graduates were absorbed by faculties in the sciences, and the remainder of them were employed in the private (250), education (256) and government sectors (38) (Cyranoski, Gilibert, Nayar & Yahia 2011).

The perceived value of doctoral graduates to the knowledge economy also influences the evolution of doctoral education worldwide. Tzanakou (2014) argues that doctoral education has currently become crucial to the knowledge economy in a number of ways. Firstly, doctoral graduates develop transferable skills (i.e. problem-solving, critical reasoning, and high-level, in-depth thinking) – skills that can be applied in various environments or workplaces. Secondly, as highly educated and trained individuals, doctoral graduates develop high-level social skills (i.e. communication, networking and engagement). The ability of doctoral graduates to build networks are synonymous with knowledge networks and developing social networks that can translate into social capital. Thirdly, doctoral graduates develop personally, and therefore are able to present themselves as individuals who can also create new knowledge and innovate independently and collaboratively. Thus, apart from the benefits to human capital, doctoral graduates develop attributes which can have a meaningful contribution beyond financial value-add.

African countries, similarly, adopted an expansionary approach to doctoral education. A recent study conducted on eight flagship universities in Africa (Bunting, Cloete & van Schalkwyk

2014) showed an increase in doctoral enrolments of approximately 8% per annum. In addition, doctoral expansion focused strongly on the postgraduate pipeline (between 2001 and 2011):

- Increased total student enrolment by 4% (doubled in growth rate)
- Increased the masters student enrolment rate 9 600 in 2001 to 25 600 in 2011 (increased to 10% p.a.)
- Doctoral enrolments increased at an average of 8%
- Academic staff grew by 4% annually
- Graduate totals more than doubled during this period
- It also showed that the combined doctoral output of these universities increased from 154 to 367 from 2001 to 2011, respectively.

In South Africa, before 1994, Bunting (1994) explains that Whites accounted for more than half of student enrolments, Indians for 35%, Coloured for 13% and Blacks for 9%. South Africa has since experienced growth in doctoral output rates especially over the last 2-3 decades; however, this is against a backdrop of a history of racial inequality within the higher education landscape. A study conducted by Cloete, Mouton and Sheppard (2015) shows an increase in doctoral enrolments between 13.3% and 13.4% between 1996 and 2015. The DHET (2016) confirms this trend in their latest report on post-schooling, indicating that in 2014, 2258 doctoral students graduated whilst 17 943 students enrolled during this time. Thus, from 2010 to 2014, doctoral graduates increased from 1420 to 2258 – a notable increase but shy of the 5000 target in 2030, as set out by the National Development Plan (NPC 2012). Expansion in South Africa's doctoral education system requires improvement of doctoral graduation rates, not only for the 8 top performing institutions in South Africa who graduate more than 80% of doctoral students, but also for the lower performing institutions (Cloete, Mouton & Sheppard 2015).

2.3.PERSPECTIVES ON DOCTORAL EDUCATION IN KNOWLEDGE CREATION

This section will briefly discuss the different types of knowledge and the models for knowledge creation. Knowledge creation should be of high quality and make an impact to the world of scholarship, and therefore should include the necessary conditions.

Knowledge creation leads to different types of knowledge, as explained by Gray (1999). Figure 2.2 provides an outline of the types of knowledge which can be created. In addition, different

types of knowledge rely on different channels and dissemination and exchange. For example, 'know what' and 'know why' knowledge relies on formal training and learning, whereas 'know how' is derived from practical experience and 'know who' is a result of social interactions, networking and relationship building (Gray 1999). Furthermore, knowledge creation is a consequence of four processes, which create the types of knowledge. The most widely known model for knowledge creation is the 'Nonaka Model', often referred to as the SECI model (Travaile & Hendriks 2010). This spiral model of knowledge creation is based on four processes. Firstly, tacit-to-tacit knowledge creation is established where socialisation in the form of face-to-face communication and social interaction creates new knowledge. Secondly, tacit-to-explicit knowledge is created by, for example, publishing or articulating knowledge, which is the main aim of most disciplines in expanding existing knowledge. Thirdly, new knowledge created by combining explicit-to-explicit knowledge, for example, developing prototypes, patents and other innovative products. Lastly, explicit-to-tacit knowledge becomes part of knowledge internalisation – often a feature of on-the-job training, much like apprenticeship. One of the criticisms of this model is the sequential nature of this proposed spiralling knowledge creation process (Gray 1999; Travaille & Hendriks 2010). Knowledge creation does not follow a sequential process, nor is it uniform in its procedures. Knowledge creation, in its diversity of processes and channels, functions as a catalyst whereby doctoral graduates can make a meaningful contribution to the knowledge economy.

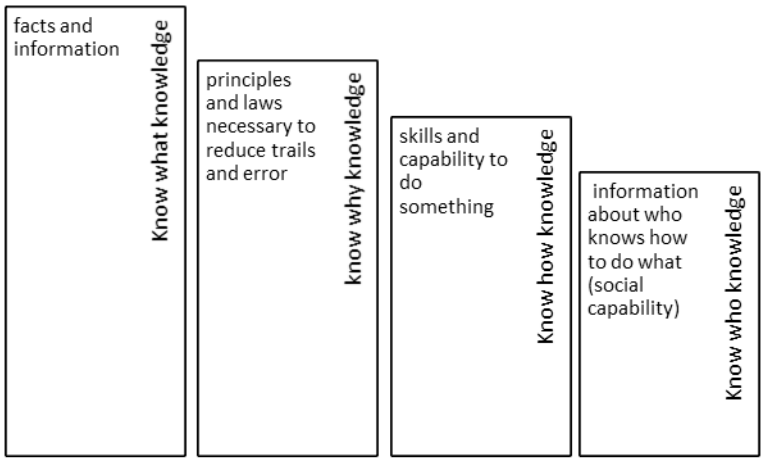

Figure 3.1: Types of Knowledge (Adapted from Gray 1999)

Jansen (2011) highlights a very pertinent question – what is the significance or impact of doctoral education? This question relates to the nature of research produced by doctoral

graduates and its potential to contribute to the world of scholarship. A number of conditions should exist for doctoral education to make a significant impact on knowledge creation which include: a) an intimate knowledge of the discipline; b) connecting the local problems to the wider class of problems; c) articulating an independent stance; d) recognising the limitation of existing research; and e) writing claims of significance around the quality of doctoral knowledge creation. Doctoral graduates, through knowledge creation, develop the necessary shared behavioural codes, trust, belonging and culture required for cognitive proximity, often within a local milieu, and acts as learning processes which are to be incorporated into systems of regional innovation (Cloete, Mouton & Sheppard 2015; Jansen 2011)

2.4.PERSPECTIVES ON DOCTORAL EDUCATION IN REGIONAL INNOVATION

Innovation consists of distinct elements which form a process conducive to regional innovation and economic development. Spill-overs offer unique benefits to regions which will be unpacked in this section. In addition to spill-overs, innovative products (i.e. IP) provides regions with economic incentives which promotes regions within a national system of innovation.

Innovation consists of three important elements: invention, innovation and infusion. Pinto (2009) explains that economic theory (technological gap theory and the new growth theory) and innovation have a critical impact on productivity and economic growth. Innovation is also important to regional science since it contributes to the manner in which we view agglomeration, urbanisation and industrialisation – one may argue that it shapes the way in which we view these processes (Cook & Memedovic 2003).

Pinto (2009: 304) also suggests that, "innovation is now transversal to all policy-making and not only a branch of each thematic policy or a particular thematic policy". Pinto (2009) raises a pertinent question on how policy-making should be aligned to innovation potential when, in fact, regions are diverse in technological, scientific and productive performance capabilities. The shift in focus of training doctoral students for the knowledge economy has been based on the realisation that scientific discovery is dependent on tacit knowledge (Altbach, Reisberg & Rumbley 2009). In addition to Pinto's (2009) observations on the link between knowledge and innovation, the Romer new growth theory (Florida 2002) also suggests that there is a link between knowledge, human capital and economic growth. Knowledge creation is used as a driver for competitive advantages whereby new products and services are created with new processes being implemented towards a region gaining a competitive advantage (Goldberg

2006; Florida 2002). An important element of knowledge creation is the fact that knowledge spill-overs occur spatially in proximity to industry and in this case, the university. There are several ways in which spill-overs and economic benefits are gained by the university, as argued by Altbach, Reisberg and Rumbley (2009). Doctoral graduates are producers and owners of intellectual capital or simply untapped stocks of ideas and inventions as well as intellectual capital (IP). Intellectual capital can become freed from the university system and may lead to potential economic development in the region (Gray 1999). For example, (Massachusetts Institute of Technology) MIT's spill-over effects include influencing a corridor of technological companies along Route 128, computer companies around Stanford University in Silicon Valley, agricultural companies around the University of Saskatchewan in Saskatoon (Canada), and the medical companies around McMaster University in Hamilton. These examples of the role of universities in regional innovation illustrates the tremendous benefits which universities can offer regional innovation and economic development (Gray 1999).

In addition, universities often engage in intellectual-property licensing. The most notable example of benefits gained from intellectual-property is that of the USA. The USA received net royalties of $1 billion in 2000, and nearly $1.6 billion for intellectual property usage. However, the ability of universities to engage in intellectual property gains/benefits depends on their ability to manage their technology transfer processes, which is lacking in South Africa. Start-ups/spin-off companies are a critical feature of the knowledge economy and localising spill-overs benefits. The commercialisation of scientific discoveries provides benefits for regional innovation. Successful spin-off companies contribute to regional economic competitiveness whilst stimulating the labour market. Industry funding is made available for research, and this benefits the processes of commercial entities, thereby increasing productivity and economic growth. As productivity increases, so does real income and GDP. Lastly, patents and products contribute to regional economies by creating a demand for products and services and ensuring that these benefits are localised (Goldberg 2006).

The wider benefits to regional innovation because of doctoral training include a highly qualified workforce, culture of innovation and increased research infrastructure capacity (Cook & Memedovic). Valero and Reenen (2016) conducted an exploratory study on the economic benefits of locations of 14 870 universities based in 78 countries and 1500 regions from 1950 and 2011. They found that the mere presence of a university in a given region resulted in faster economic growth. They also found that by doubling the number of universities in a given

region, economic prospects are improved by at least 4% in higher growth domestic products (GDP) per capita and that those universities offering doctoral qualifications had the greatest effect on GDP.

CHAPTER 3: RESULTS AND DISCUSSION

This chapter will discuss the demographic, educational and socio-economic characteristics of doctoral graduates at Stellenbosch University between 2010 and 2015. This chapter will attempt to provide insight into the profile of doctoral graduates at Stellenbosch University in order to understand their role/function within knowledge creation and regional innovation. The analysis of these variables will assist in profiling doctoral graduates and unpack their role in creating knowledge and regional innovation.

3.1. DOCTORAL GRADUATE PROFILE

3.1.1. Demographic characteristics

Doctoral graduates are diverse in terms of race and gender, age, nationality and home-language, based on the data retrieved from the institutional dataset [3] (Stellenbosch University 2016). The majority of graduates are White (61%) and Black (26%) (n=1290). In terms of gender, the majority of graduates (60%) during this period are male (Figure 3.1). The results also show that an average[4] of 69 White males and 62 White females graduate with a doctoral degree at Stellenbosch University compared to an average of 15 Coloured males and 9 Coloured females per year.

Although graduates appear as diverse upon first glance, the results indicated above still shows that Stellenbosch University is largely producing a majority of white graduates compared to the population composition in the Western Cape. In contrast to the output of doctoral graduates at Stellenbosch University, Coloureds make up 49% of the entire population in Western Cape, followed by Blacks (33%) and Whites (16%) (Statistics SA 2012). This demographic statistic in terms of doctoral graduate output has the potential to skew the supply of highly skilled human capital for the province, favouring the white minority. Historically, the rate of non-White graduates was far behind their White counterparts (Bunting 1994) and these trends still shows

[3] The institutional dataset consisted out of 1290 entries of doctoral graduates from 2010-2015.
[4] Average calculated for totals (from 2010-2015) retrieved from institutional data sources

racial inequality in the production of doctoral graduates 21 years post the abolishment of Apartheid.

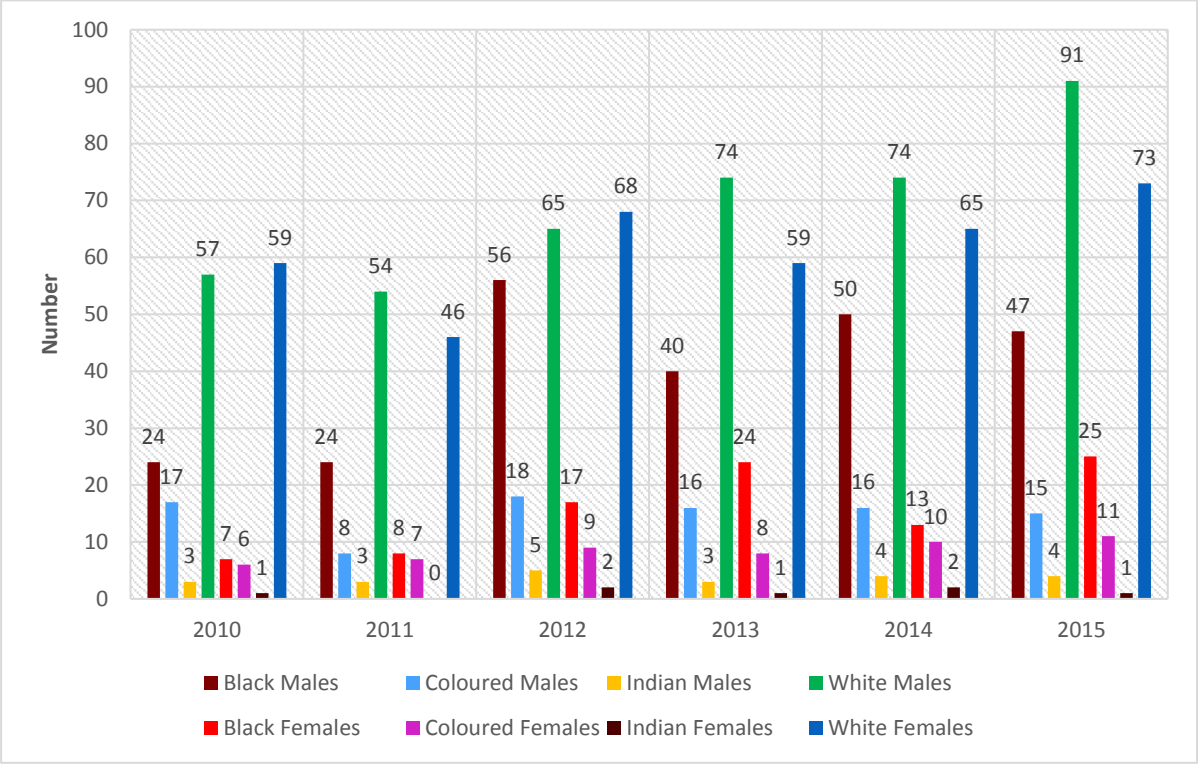

Figure 3.1: Race and gender of doctoral graduates at Stellenbosch University from 2010-2015

In contrast to the differences between race and gender, the age at graduation between the various racial and gender groupings are quite similar, as illustrated by Figure 3.2. The average age at graduation is 38 years for most of the demographic groupings. Indian females and Coloured males are the eldest at graduation (39) whereas White females are much younger (35). The ASSAF study (2010) showed that 39% of doctoral graduates from 2000-2007 were between 30-39 years old, which was also the largest age grouping. This figure suggests that Stellenbosch University graduates are within the norm given the age distribution reported by the ASSAF (2012). However, the outlier average age of White females could be explained by the fact that the DST ministerial guidelines for student support allows for White females to be counted as part of the 55% ratio of total student supported which is aligned for the South African Government's objective of inclusion and gender equality (NPC 2012; National Research Foundation 2016). This allowance is despite the fact that historically, White females were not excluded from higher education to the same extent as, for example, Black males or Black females.

The age at graduation is also some indication of which stage of life doctoral graduates find themselves in. The pressures on males and females differ based on their stage of life. This, in turn, could factors into the ability of doctoral graduates to succeed in their doctoral studies, i.e. the life stage of single young women and young women with children experience more family/private pressure, whereas single young men and young men with children experience the most pressure related to work (Wepfer, Brauchli, Hammig & Bauer 2015). Social changes over the last few decades have seen more women representation in all sectors of work. However, the expectations of these women who work and study full-time remains the same. In order to increase the doctoral output for women in general, and Black women in particular, doctoral education strategies should factor the family/pressure load on women who want to study towards a doctoral qualification, for example, allowing part-time bursaries for those women who have young children (Wepfer et al. 2015).

In addition, the age at graduation impacts on graduate throughput, which takes into consideration the duration from undergraduate to postgraduate studies and eventually leading up to doctoral studies (Cloete, Mouton & Sheppard 2015). One may deduce that it would take approximately 20 years for a high school graduate[5] to eventually graduate with a doctoral degree. Strategies should be structured around a 20-year period instead of 5-10 year period in order to effectively evaluate impact and correction. Such long-term strategies should be considered when formulating future policies regarding the expansion of the South African doctoral education system.

[5] Estimated to be 18 years old at age of high school matriculation

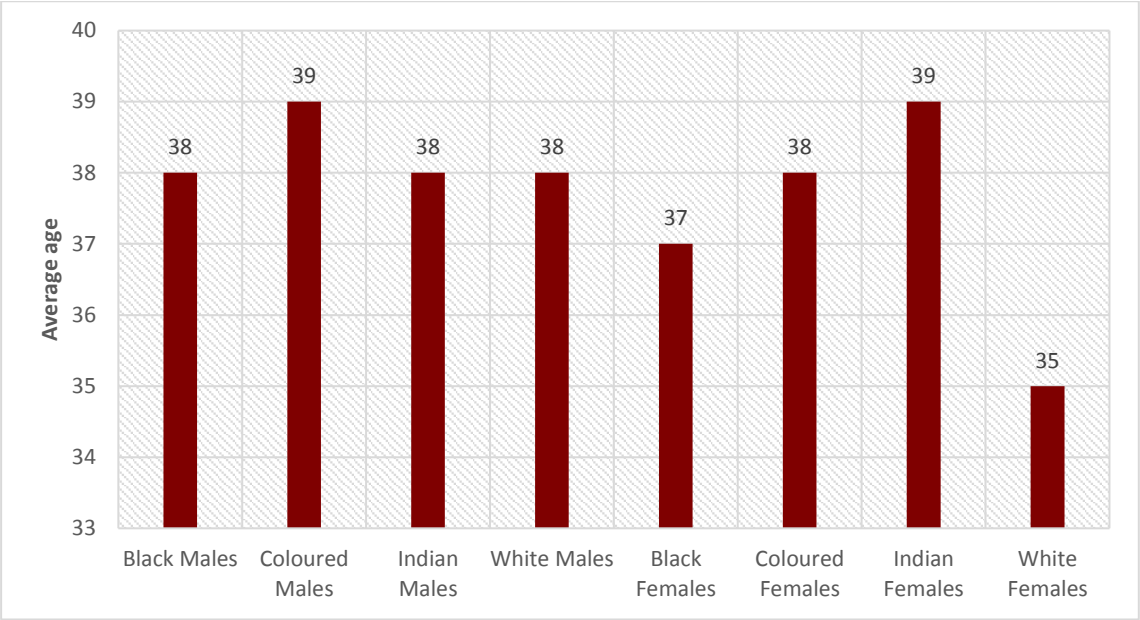

Figure 3.2: Average age at graduation of doctoral graduates at Stellenbosch University (from 2010 to 2015)

Internationalisation of higher education increases the expansion of doctoral education but may lead to inequality in terms of the ratio of local graduates. Graduates at Stellenbosch University originate from 53 countries around the world (Table 3.1[6]). Interestingly, 903 graduates are South African followed by 66 Zimbabweans, 35 Nigerians, 26 Kenyans, 24 Americans, 21 Ugandans, 18 Namibians, 17 South Koreans, 17 Libyans and 16 Malawians, comprising the top 10 nationalities (n=1290). Doctoral degree expansion has catapulted by increased globalisation and internationalisation (Cloete, Mouton & Sheppard 2015). The institutional data shows that 70% of graduates at Stellenbosch University were South African citizens, compared to the national trend of 61% (HSRC 2017). The majority of international students are from the African continent, which affirms Stellenbosch University as a regional and continental hub for doctoral education.

On the contrary, from the 335 graduates who indicated [7] themselves as Black, only 78 (23%) of them are South African. To this point, only 6% of all doctoral graduates at Stellenbosch University between 2010 and 2015 were Black South African citizens. Such a low figure is likely due to historical inequality within the South African higher education system and strongly

[6] Data retrieved from the institutional dataset on doctoral graduates
[7] Graduates self-select their race for classification purposes. It may therefore not be a true representation in terms of the South African race classification (e.g. Black, Coloured or Indian).

suggests a perpetuation of this trend, currently. Black student graduations were quite low considering that Blacks represent 33% of Western Cape residents and 79% of the entire population in South Africa (Cloete, Mouton & Sheppard 2015; Statistics SA 2012). Increasing the rate of graduation for the region and country could be improved, dramatically, if doctoral policies are specifically aimed the graduations of majority of students.

Table 3.1: Top 10 Nationalities of doctoral graduates

Nationality	**Black**	**Coloured**	**Indian**	**White**	**Total**
Malawi	16				16
Libya		12	5		17
South Korea		4	2	11	17
Namibia	9	1		8	18
Uganda	20			1	21
USA (United States of America)	1			23	24
Kenya	26				26
Nigeria	33	1		1	35
Zimbabwe	64			2	66
South Africa	78	117	12	696	903
Total	335	141	29	785	1290

Internal mobility of doctoral students is central to the discussion of regional innovation (ASSAF 2010). In other words, regional disparities provides different opportunity for the movement of labour, skills and expertise. Figure 3.3 shows that the overwhelming majority of doctoral students reside in the Western Cape, benefitting from the close proximity to Stellenbosch University. This locational relationship will be discussed more comprehensively under Section 3.2. It is necessary to note that Gauteng is the province with the second highest doctoral graduates. Gauteng is the economic hub of South Africa and boasts the largest population in the country (Stats SA 2012). The fact that Gauteng had the second largest number of doctoral graduates (9%), illustrates that some doctoral graduates were willing to re-locate in order to study at Stellenbosch University. (n=1067). The Northern Cape (1%) has the lowest number of

graduates at Stellenbosch University despite higher percentage Afrikaans-speaking residents than the Western Cape; given that Stellenbosch University is a historically Afrikaans medium institution (Stats SA 2012).

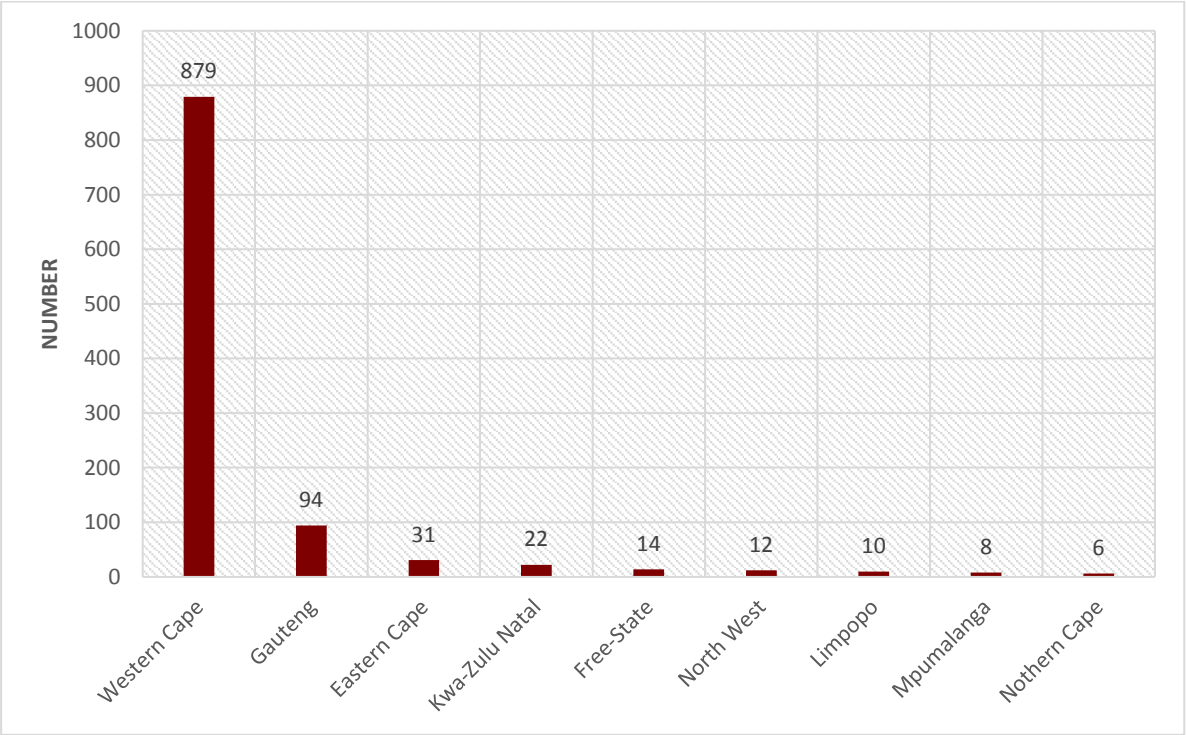

Figure 3.3: Home province of graduates at Stellenbosch University (from 2010-2015)

Finally, home-language provides another key characteristic for doctoral graduates. English is the most common home-language for doctoral graduates at Stellenbosch University (43%) followed by Afrikaans (40%) (n=1290). White graduates accounted for 90% of the total Afrikaans speakers (Figure 3.4). According to Statistics SA (2012), 50% of Western Cape residents are Afrikaans speakers followed by Xhosa speakers (25%) and English speakers (21%). ASSAF (2010) found that the majority of doctoral students in South Africa are English speakers, similar to the Stellenbosch University graduates. One may also deduce that Afrikaans instruction benefits mostly White graduates and that this high number of Afrikaans speakers necessitates dual-medium instruction languages at Stellenbosch University.

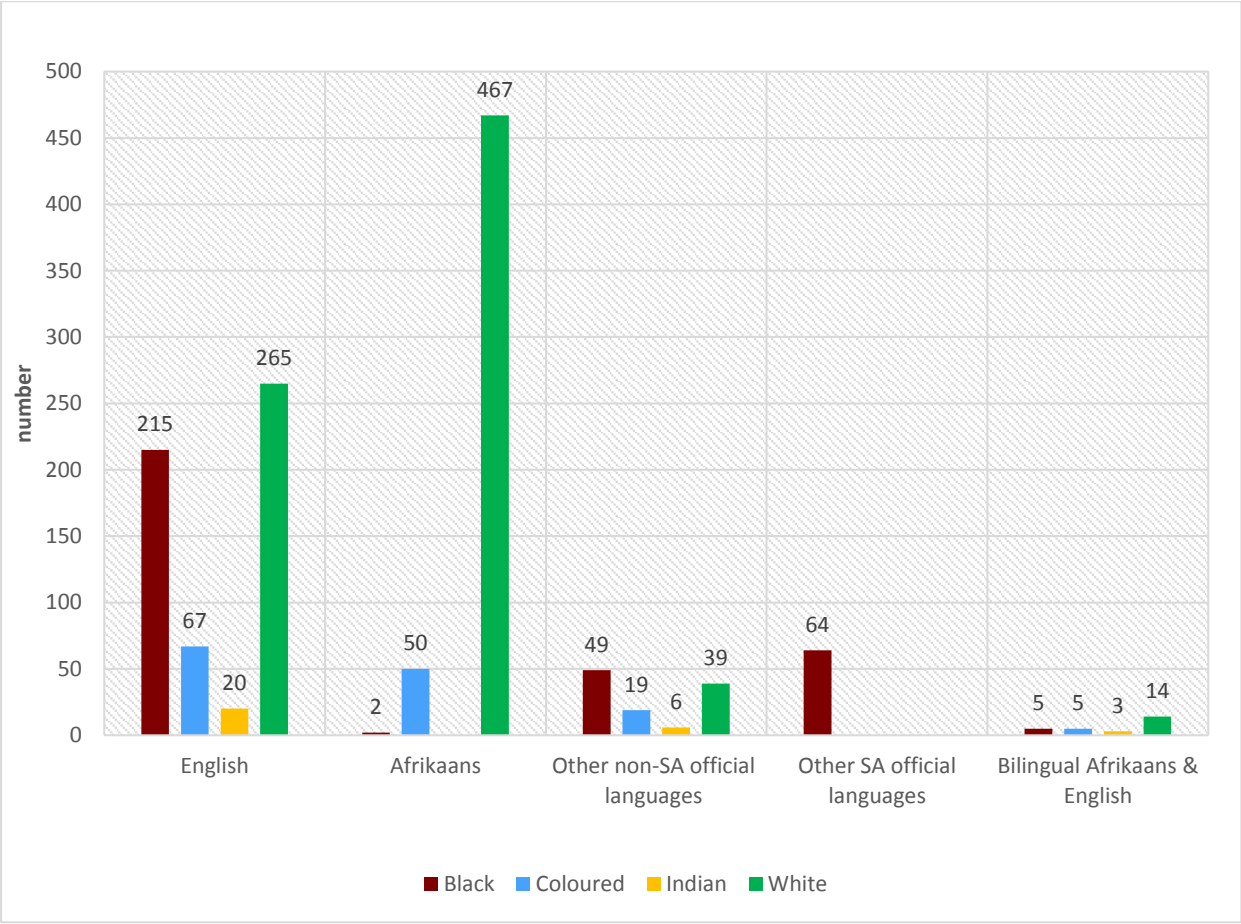

Figure 3.4: Home-language of doctoral graduates at Stellenbosch University (from 2010 to 2015)

3.1.2. Educational profile of doctoral graduates

This section aims to unpack the educational characteristics of doctoral graduates at Stellenbosch University from 2010 to 2015. To this end, the discussion will start with the faculty distribution of graduates, the research areas/themes that doctoral graduates study, educational history (previous programmes), the structure of their degrees, and motivations behind their decision to study at Stellenbosch University (pull factors).

Doctoral outputs at Stellenbosch University have a) increased significantly from 2010-2015, stimulated by b) underlying factors and directed towards c) certain policy objectives (i.e. promotion of scarce skills [SET]). Almost all of the 10 faculties offering doctoral programmes at Stellenbosch University increased their doctoral graduate output from 2010 to 2015, with the exception of the Military Sciences faculty which introduced a doctoral degree programme in

2013/2014 (Figure 3.5). The highest number of graduates were from the faculties of Science (24%) and Arts and Social Sciences (19%) (N=1290). Figure 3.5 illustrates that 2015 had the highest number of doctoral graduates at Stellenbosch University. Faculties experienced fluctuations in their individual doctoral output. For example, Arts and Social Sciences had 56 graduates in 2012, which is higher than the 43 doctoral graduates in 2015. Similarly, the Faculty of Science produced 63 doctoral graduates in 2012, which is higher than the 55 graduates during 2015. Furthermore, the faculties of Agriscience and Engineering experienced a rapid increase in doctoral graduates between 2014 and 2015 whereas Theology, and Medicine and Health Sciences experienced a slight decrease in doctoral graduations. This trend shows that predicting doctoral output trends at the institutional level is critically dependent on interventions at faculty level.

The fluctuations at the faculty level could be explained a variety of faculty level factors. For example, variations in completion rates (some students taking longer than others, per faculty), policies and strategies aimed at improving the graduate output for certain research area specialities (institutional plans) and institutional capacity to train a larger cohort of doctoral students (Pedersen 2014). In addition, this trend shows that there is a gradual increase in the output of SET graduates, which allows for more high-level skills in for the region and country, especially regarding the promotion of innovation required for competing in the knowledge economy. These graduates are assumed to contribute significantly towards innovation and the creation of new technologies (Pedersen 2014). Large cohorts of doctoral students are trained at Centres of Excellence, a Department of Science and Technology and NRF programme, which promotes collaborative supervision among institutions and nodes, provides funding for increased student outputs at master's and doctoral level and directs this output towards fulfilling the objectives of the networking and collaboration, information brokerage, service rendering, knowledge production and education and training. These Centres of Excellence commenced in 2009 and the first cohort of funded doctoral graduates passed in 2011 (National Research Foundation 2016). Stellenbosch University has five Centres of Excellence in various research areas: SACEMA (DST-NRF South African Centre for Epidemiological Modelling and Analysis), SciSTIP (DST-NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy), CIB (Centre of Excellence in Invasion Biology), CBTBR (DST-NRF Centre of Excellence in Biomedical TB Research) and NIThEP (National Institute of Theoretical Physics).

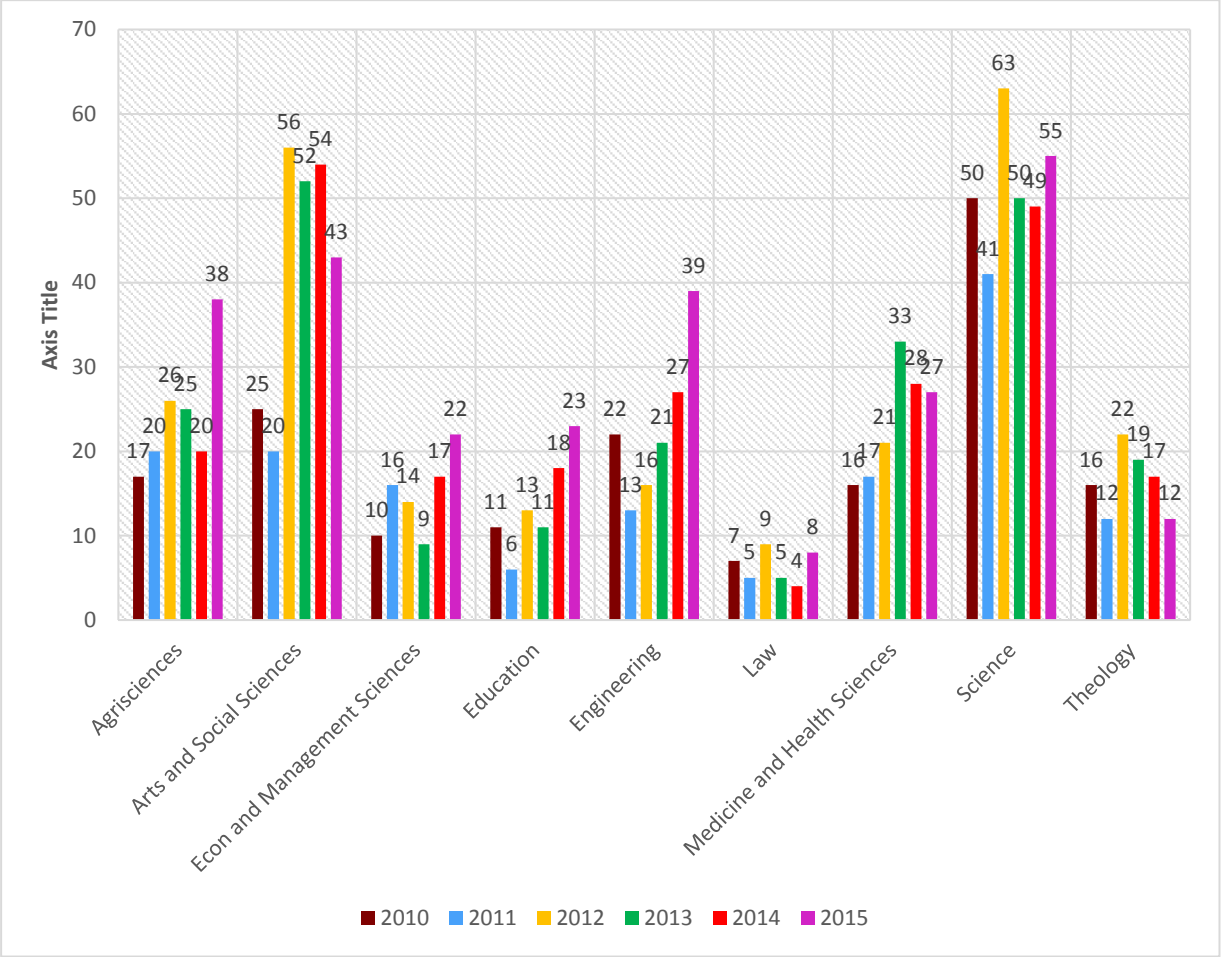

Figure 3.5: Faculty distribution of doctoral graduates at Stellenbosch University (from 2010 to 2015)

Doctoral graduates studied 132 different research areas/themes during 2010 and 2015. Table 3.2 below provides a summary of the top 10 research areas/themes. The Department was used as proxy for the research area/field. It should be noted that the top 10 fields account for 37% of all doctoral graduates, which could indicate a degree of institutional expertise and specialisation. Furthermore, certain fields only graduated one doctoral student between 2010 and 2015 (e.g. Accounting or Histology), indicating a greater degree of institutional specialisation, especially in professional qualifications such as accounting (See Addendum B). The top 10 fields below comprise mostly SET fields with the exception of a high number of graduates from Theology and Curriculum studies. South Africa requires increased output of SET doctoral graduates in order to increase its potential to innovate and compete in the global knowledge economy. Increasing the number of SET doctoral graduates Stellenbosch University aligns with the National Development Plan's objective to ensure that SET graduates form the

bulk of the 5000 graduate target set by the NPC (2012). Again, Table 3.2 shows that studies in doctoral education should focus on micro-level movements in output even though an overall target in doctoral graduates can be quite useful. Failure to articulate and track micro-level movements in research areas presents a particular challenge for understanding the trends in doctoral education (Pedersen 2014). Table 3.2 shows the number of graduates per discipline per year with the numbers in red highlighting the greatest number of graduates for each subject.

Table 3.2: Research areas/themes studied by doctoral graduates at Stellenbosch University (from 2010-2015)

Research Areas / Themes	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Grant Total**
Chemistry and Polymer Science	12	17	19	11	10	9	78
Practical Theology and Missiology	9	8	14	11	14	6	62
Biomedical Sciences	9	7	10	13	9	9	57
Curriculum Studies	6	5	9	4	12	15	51
Botany and Zoology	6	4	11	7	8	8	44
Physics	7	4	5	6	10	11	43
Electrical and Electronic Engineering	10	2	4	9	8	9	42
Conservation Ecology and Entomology	6	5	5	10	6	6	38
Mathematical Sciences	4	4	9	5	4	7	33
Process Engineering	6	4	5	5	5	8	33
Total	174	150	240	225	234	267	N=1290

One such micro-level indicator is the structure of the degree. Degree structure provides a useful tool for estimating the duration of the study as well as possible implications for funding. The majority (59%) of survey respondents were registered as full-time students (n=80) (Figure 3.6). Full-time students improve the progression of higher education studies and increase the rate of retention much more than part-time students. Full-time students complete their degree in 3-4 years whereas part-time students complete their degrees in 5-6 years (Cloete, Mouton & Sheppard 2015). In addition, full-time doctoral students have the benefit of not having to balance work and studies at the same time and can easily be recruited into academic positions after completion of studies (Pedersen 2014). The fact that the National Research Foundation's scholarship funding at doctoral level is capped at a maximum of 3 years on a full-time basis, compared to part-time doctoral degrees that are funded for 5 years at a much lower amount, which supports the national priority and preference of full-time studies versus part-time studies (National Research Foundation 2016). Furthermore, the government has developed a number

of interventions to graduation of full-time students, e.g. the NRF Doctoral Innovation Scholarship programme, the NRF Doctoral Scarce Skill Innovation scholarship programme and the NRF freestanding scholarship programme which are exclusively aimed at funding full-time students (National Research Foundation 2016).

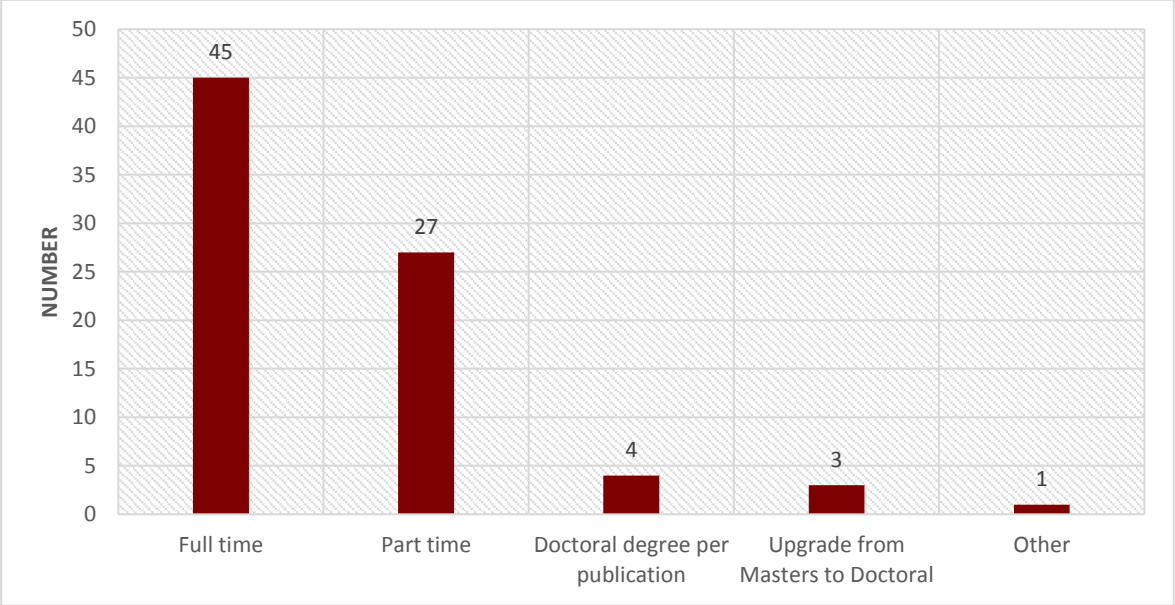

Figure 3.6: Programme structure of doctoral degrees at Stellenbosch University (from 2010-2015)

The degree structure is a useful indicator of how long students might take to complete their studies, however, it does not provide a sense of the quality of the doctoral graduates. The quality of doctoral graduates is very difficult to study or quantity. What this study will consider is underlying motivations for doctoral studies – the motivating factors behind why graduates decided to complete a doctoral qualification. Survey results show that doctoral graduates are motivated by various (pull) factors – staff expertise (specialised skills) and institutional reputation, supervisory capacity or connections and location (proximity).

Staff expertise and institutional reputation were uncovered as key motivating factors for doctoral graduates. The expertise of the academic staff is a key consideration for 25% of respondents (n=87) (Figure 3.7). In other words, doctoral graduates are looking for supervisors with a proven record of success. Interestingly, Stellenbosch University has 430 rated scientists/researchers [8] as per the National Research Foundation Rating system, which makes it

[8] A rated researcher should have international standing in their respective fields.

an attractive choice in terms of the expertise and excellent research experience in their respective fields (Stellenbosch University 2016). Furthermore, Stellenbosch University has 13 A-rated researchers of international standing in fields such as paediatrics and childcare, chemistry and polymer sciences, mathematical sciences, botany and zoology and private law (Stellenbosch University 2016). In addition, the reputation of the institution influenced the decision of 13% of respondents (n=87), which means that doctoral graduates are looking at institutions that are well equipped and maintained with, again, a proven record of success. The attractive reputation of Stellenbosch University may be attributed to its improvement in the World University Rankings, ranking in the 401-500th category in the world and 4th in Africa (Stellenbosch University 2016).

Supervisory capacity and existing connections with supervisors at Stellenbosch University is also an important consideration for 14% of respondents. The fact that supervisor capacity and existing connections were uncovered as motivating factors, could be linked to the throughput of master's students (who have built connections with existing supervisors). These students have already chosen a supervisor during their Masters studies and are continuing with the same supervisor into doctoral studies. It is probably also true that co-supervision by staff at different institutions and the general good standing (visibility) of certain academics in their respective fields builds connections between students and supervisors (Sehoole 2011).

Interestingly, 9% of respondents indicated that they choose Stellenbosch University due to its geographic location (proximity). Central to this study is the ability of universities to leverage its location to the benefit of the region and its residents. It is therefore not surprising that some respondents choose Stellenbosch University since its proximity was favourable. There are a number of other considerations related to this factor. These include, for example, savings in cost of travel and accommodation, proximity to a support system in the form of family and friends and students being able to make better use of the physical institutional infrastructure (i.e. laboratories, computer facilities, etc.) as opposed to those students who live outside Stellenbosch or the Western Cape. One respondent indicated, *"Undergraduate and masters was done at Stellenbosch. Facilities are good, lecturers are good and support from other universities is also good. Already located in the area with friends and family close-by".* Cloete, Mouton and Sheppard (2015) maintain that the overall majority of university students indicated that funding remains the biggest obstacle in their path to completion. Proximity to institutions,

with its cost saving benefits, surely ties into this argument and proposes sufficient motivation for these doctoral graduates in choosing the most appropriate institution. It should also be noted that no singular factor is assumed as the only consideration when choosing a university, and it is most probably a combination of these factors that leads to the ultimate decision. Of the respondents, 32% of doctoral graduates are not from the region, as discussed under Section 3.1.1 and did not make their decision of university based on proximity.

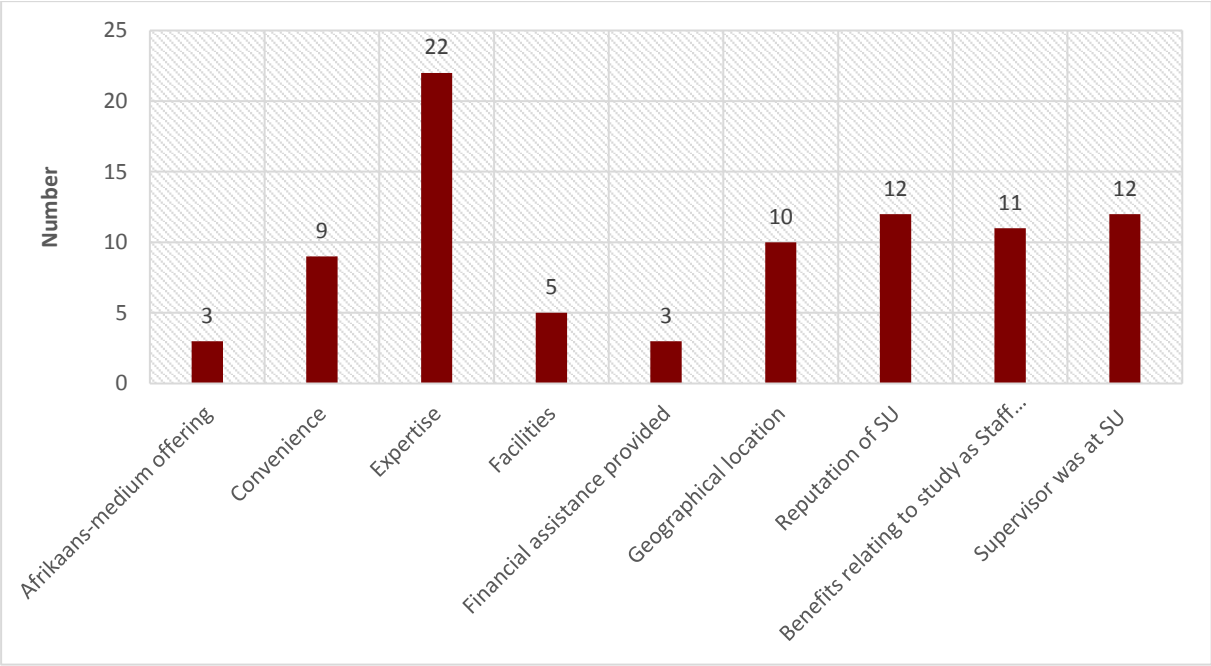

Figure 3.7: Survey result "Why did you specifically choose SU to complete your doctoral degree?"

Student mobility, mirroring international mobility and exchange, is affected by various push and pull factors, as discussed above (Sehoole 2011). Doctoral graduates come from various institutions prior to completing their doctoral degrees at Stellenbosch University. The data presented in Figure 3.8 only includes South African universities and the University of Zimbabwe (excluding Stellenbosch University since these students are assumed to have already decided to study at Stellenbosch University during their postgraduate studies). Previous qualifications obtained by doctoral graduates were from mostly South African institutions. A high number of graduates previously studied at the University of Cape Town (150) and the University of the Western Cape (148), institutions located in the same province. A high number of degrees were obtained from the University of Pretoria and the University of South Africa.

Increased mobility requires greater standardisation in terms of assessments, entrance requirements, pedagogy, etc. between these institutions (ASSAF 2010)

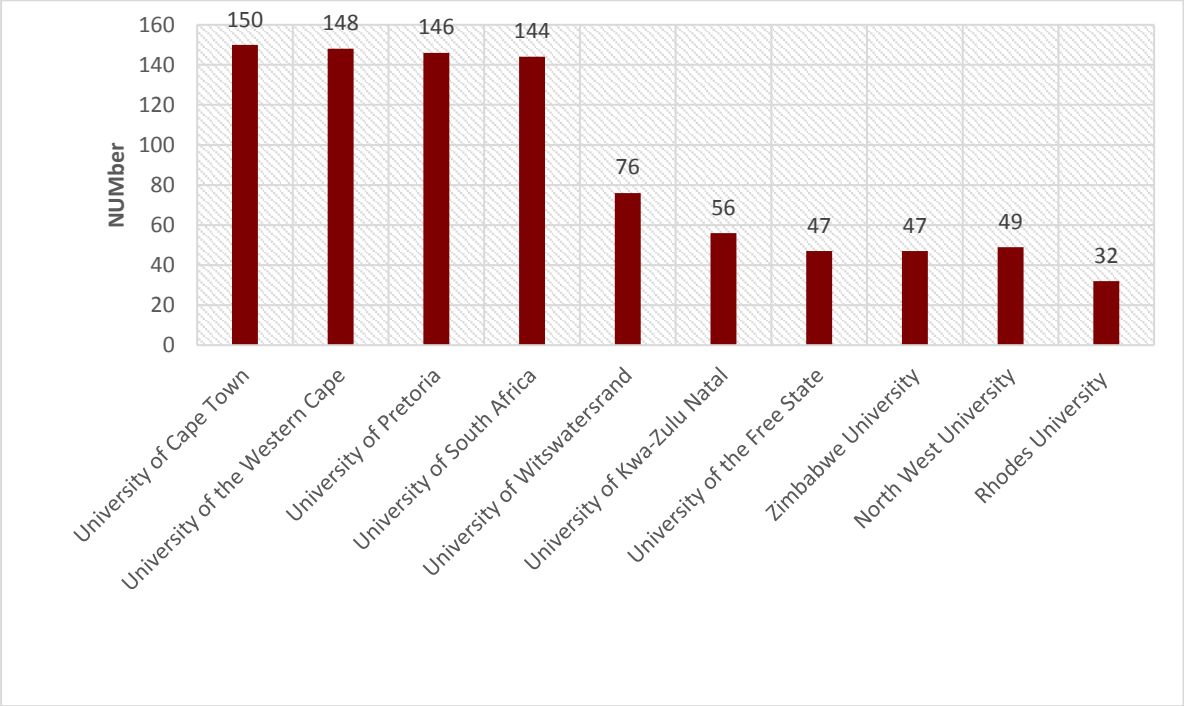

Figure 3.8: Previous institutions of study for doctoral graduates at Stellenbosch University (from 2010-2015)

3.1.3. Socio-economic characteristics of doctoral graduates

This section will profile doctoral graduates in terms of their occupations, income levels, and their perceptions about present income, funding sources to complete studies (financial need) and household size.

Doctoral graduates study diverse research areas/fields and, subsequently, become skilled in various occupations. Figure 3.9 shows that 24% of graduates are employed as lecturers (n=62). In addition, 16% work as research assistants and 8% are employed as researchers. According to the HRSC (2017), 61% of all research and development staff are currently employed in the higher education sector which reflects the sector's vital role in the national research and development landscape. In other words, currently, the potential for regional innovation and knowledge creation is highly clustered in the higher education sector. It is therefore not

surprising that most of the jobs listed by doctoral graduates are directly or indirectly aligned to the higher education sector. However, the higher education sector has a limited number of vacancies available per year for absorbing the number doctoral graduates (ASSAf 2010). There is a general assumption that doctoral graduates are overqualified for jobs in the private sector however another conception exists, that the private sector is unable to attract the number of doctoral graduates required (Pedersen 2014). If the private sector is unable to attract doctoral students, one my deduce that this reflects a lack of policies or strategies which direct doctoral outputs towards certain key sectors requiring scarce skills, which in turn could increase the potential for knowledge creation and regional innovation outside the higher education sector i.e. the National Development Plan does not specify which sectors doctoral graduates are needed (Pedersen 2014). The table below shows the various occupations of Stellenbosch graduate participants.

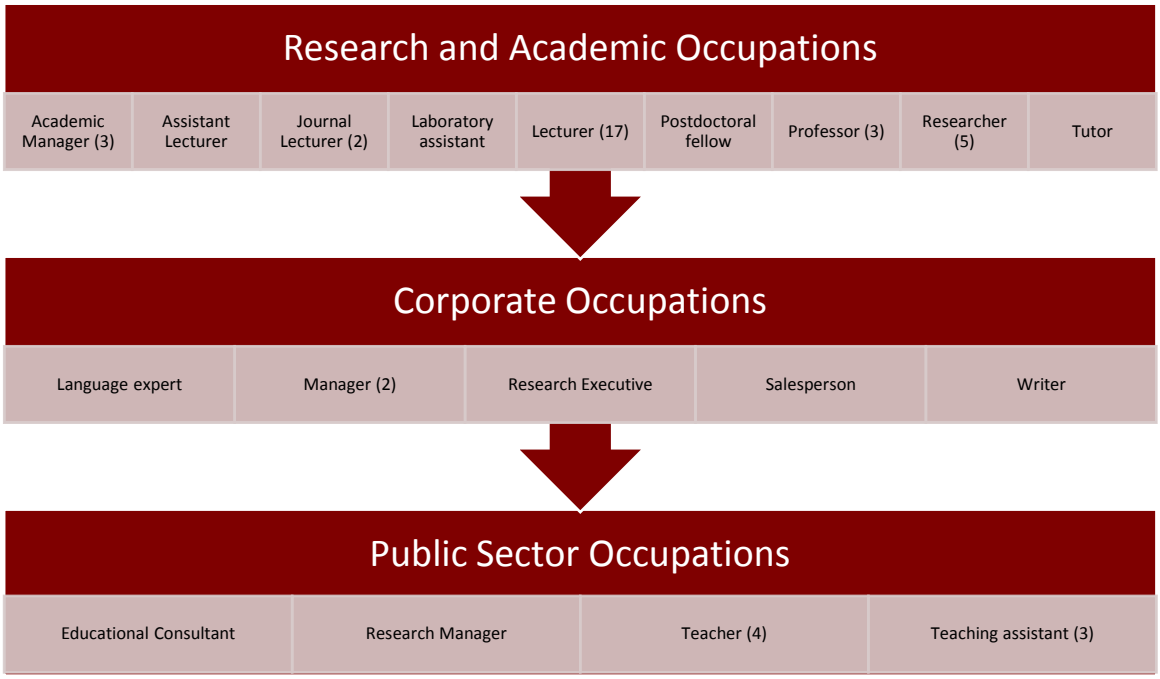

Figure 3.9: Occupations of doctoral graduates, post-2015 graduation at Stellenbosch University (from 2010-2015)

Doctoral graduates are highly skilled and qualified and therefore secure high-level jobs with accompanying remuneration packages (Cloete, Mouton & Sheppard 2015). Figure 3.10 illustrates that most graduates (63%) earn between R307 601 and R1 228 800 per annum (n=75). Recent salary scales at Stellenbosch University indicate that a junior lecturer earns between R322 416 and R429 888, a lecturer earns between R419 445 and R559 260 and a senior lecturer earns between R520 101 and R693 468 (Stellenbosch University 2017). Furthermore, an

associate professor earns between R620 820 and R827 760, a professor earns between R 759 816 and R1 013 088 and a distinguished professor earns between R 842 400 and R1 123 200, per annum. The majority of respondents (63%) therefore earn commensurate with that of a junior lecturer upwards to a distinguished professor. On the other hand, doctoral graduates in support staff may earn between R700 542 and R934 056 per annum that is commensurate with the salary scale of an associate professor or professor. Doctoral graduates are also able to cross over into other sectors due to their valuable high-level transferrable skills (Nerad & Evans 2014). Salaries remain an important, if not the most important, element of job retention. Salary scale revision may increase the mobility of doctoral graduates between various sectors, thereby increase the transfer of knowledge and skills (transferrable skills) (Pedersen 2014).

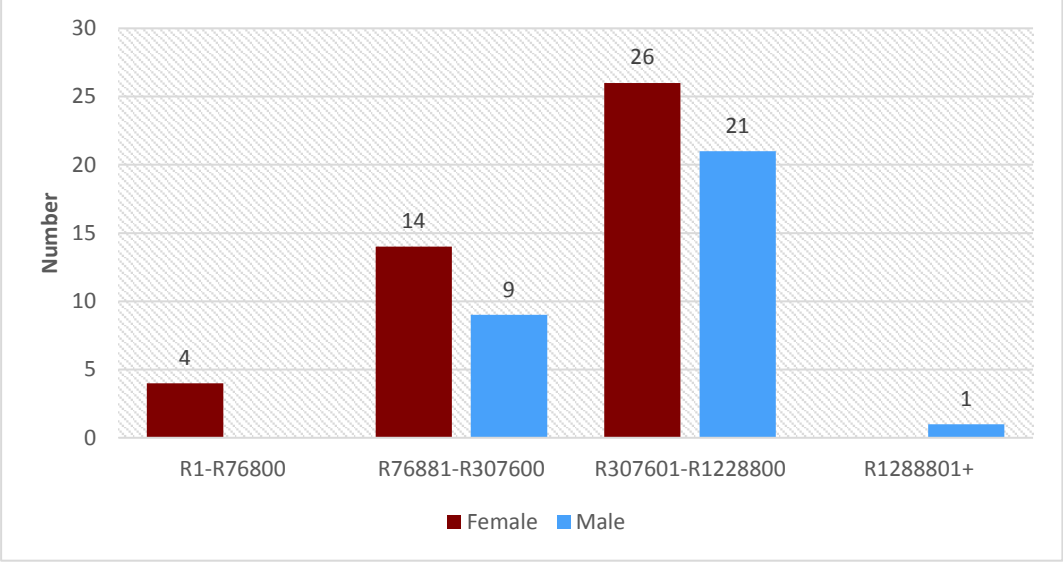

Figure 3.10: Income categories per gender of doctoral graduates at Stellenbosch University (from 2010-2015)

Figure 3.11 illustrates that graduates are content, largely, with their current income (83%). Salary provision, especially in the higher education sector, follows a career path from junior lecturer to full professor. It is therefore not surprising that most respondents indicated that they are either living comfortably or coping on present income. They are able to plan sufficiently for adverse events, and increases in gender equality (the employment of more women at university) increases the probability for dual-income households. However, this is not the same in the private sector where salaries are very much determined by individual companies and lack market alignment – low salary levels, for instance, is one of the factors to blame for 'brain drain' (ASSAF 2010; Cloete, Mouton & Sheppard 2015).

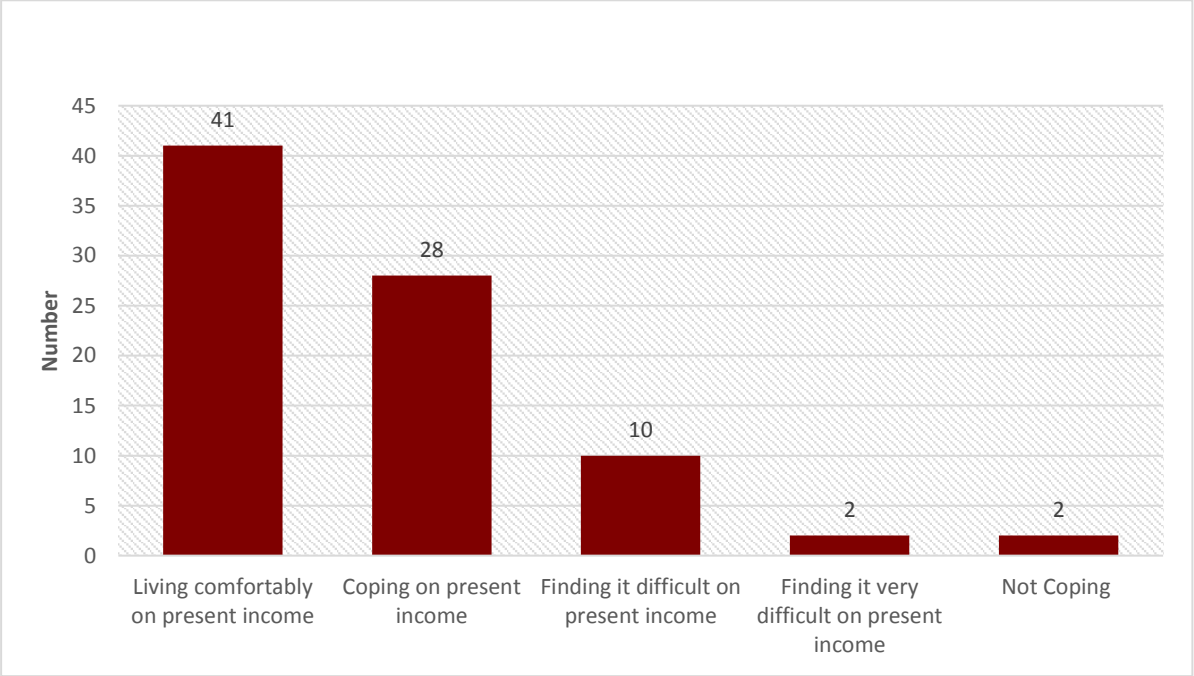

Figure 3.11: Perceptions of present income of doctoral graduates at Stellenbosch University (from 2010-2015)

In addition to salaries, household size offers insight into the economic burden faced by doctoral graduates. Figure 3.12 shows, that although salaries might be relatively high considering the high levels of poverty in South Africa (Statistics SA 2012), the economic burden differs from person-to-person. The majority of graduates (38%) have household sizes of 2 persons whereas 42% have at least more than 2 and less than 7 people in their households (n=80). The average household size in South Africa is 3.6, which is the same for the Western Cape (Statistics SA 2012). Doctoral graduates' households are similar to the average household size for the country and region, but those who have more persons per household (e.g. 5-10) require greater support. In order to attract and retain doctoral graduates, more programmes should focus on work-life balance. Stellenbosch University's Faculty of Medicine and Health Science, for example, is in the process of building a state-the-art 17-classroom nursery with a capacity of 350 learners aimed at ensuring a better work-life balance, increased quality of life for its staff and better retention, in the end. In addition, Stellenbosch University uses household size as one of its criteria for scoring financial need (Stellenbosch University 2016), which can assist those students with larger households and accompanying financial pressures.

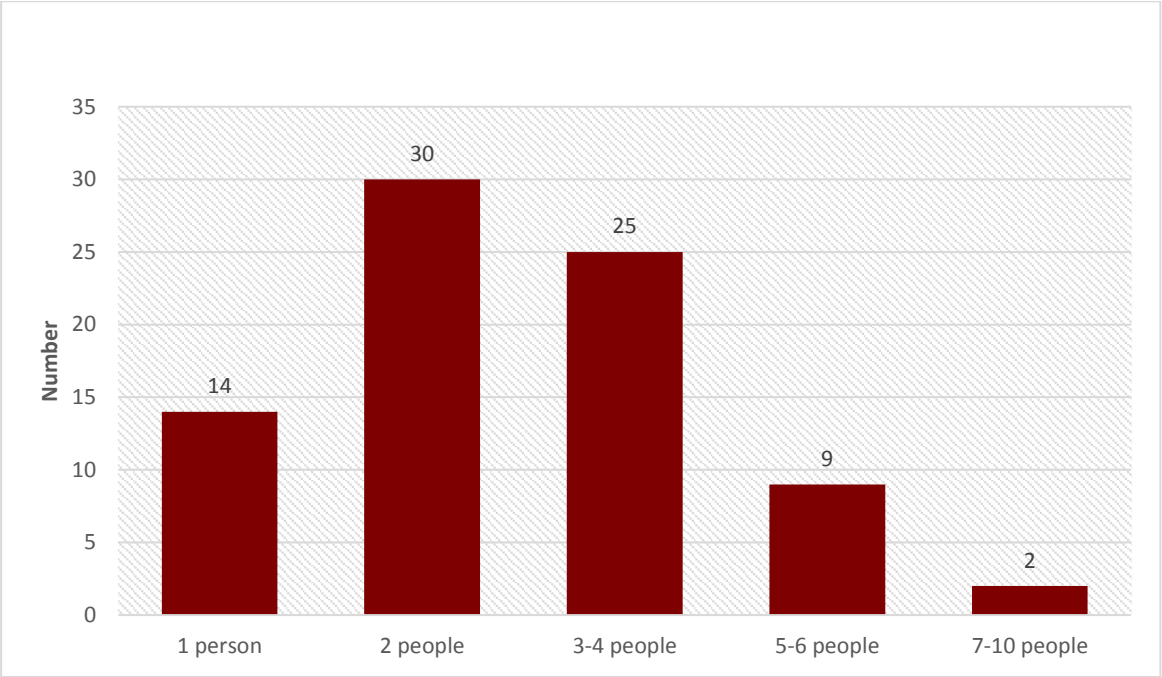

Figure 3.12: Household sizes for doctoral graduates at Stellenbosch University (from 2010-2015)

Financial pressure or funding has been indicated as the biggest obstacle for students in completing their studies, as mentioned above. Survey results, reflected in Figure 3.13, show that doctoral graduates were largely (22%) funded by Stellenbosch University (n=188). Institutional funding for doctoral studies is dependent on the availability of institutional sources of funding as well as the number of doctoral students who require funding (financial need) (Stellenbosch University 2016). A large number of students (19%) were funded by the National Research Foundation (NRF), reiterating the importance of the role of government to support doctoral studies by providing funding support to students. Figure 3.13 illustrates a number of diverse funding sources and alludes to students being reliant on external support in order to complete their degrees. Industries or corporations funded a smaller number of students, which, if increased, can provide some relief to students and institutions.

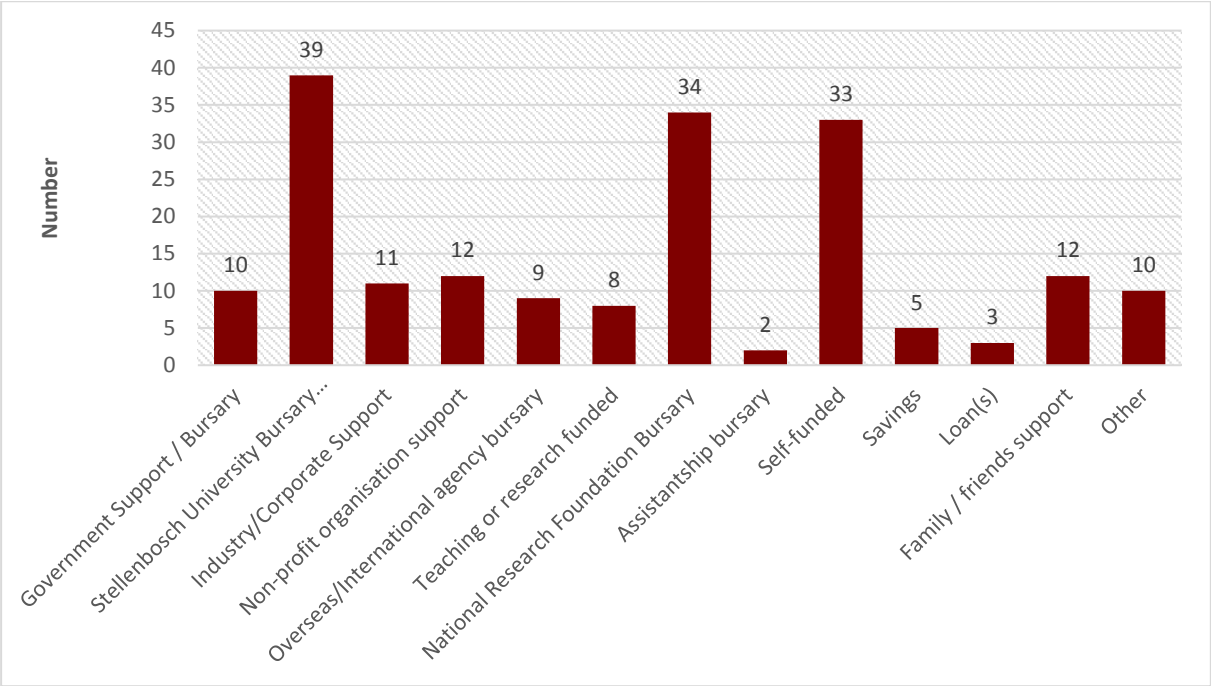

Figure 3.13: Funding sources of doctoral graduates at Stellenbosch University (from 2010-2015)

Herman (2011) explains that in 2009, the average bursary was around R40 000. Interestingly, in 2017 this amount is increased to around R60 000-R90 000 but still falls short of the level of funding required (National Research Foundation 2016). The recent #FeesMustFall student protests highlighted, once again, the economic burden experienced by lower to middle income households and reiterated the call to the South African government to revise its funding frameworks and institute a free higher education policy. The South African government currently only contributes 40% of universities' budgets, which is much less than the 49% in 2000. In addition, only 0.7% of its gross domestic product (GDP) is allocated to higher education (Karodia, Soni & Soni 2016).

3.2. DOCTORAL GRADAUTES' ROLE IN KNOWLEDGE CREATION AND REGIONAL INNOVATION

Central to the discussion on the role of doctoral graduates in knowledge creation and regional innovation is the knowledge and innovation products that graduates generate. In addition, this section will unpack some of the perceptions of graduates regarding their role in terms of knowledge creation and regional innovation.

3.2.1. Knowledge and innovative outputs

Survey results, in Table 3.3, show that doctoral graduates published 3.25 per capita articles out of their doctoral dissertations. This is quite high since the publication output for Stellenbosch University staff is 1.32 (Stellenbosch University 2016). This figure means that doctoral graduates are more productive than general Stellenbosch University academic staff. This high publication output per capita could be explained by a renewed push by the South African government for doctoral graduates to publish articles from their dissertations (Cloete, Mouton & Sheppard 2015). In addition, recent doctoral graduates are encouraged to apply for NRF-Thuthuka and the NRF-Development grant for Y-rated Researchers funding instrument in order to promote the publication of research articles, reinforcing the call for doctoral graduates to increase their publication output (National Research Foundation 2016). In addition, Stellenbosch University has had the highest number of weighted research outputs (publications and students) in South Africa for the past 7 years (Stellenbosch University 2016). Table 3.4 lists the most popular journals per publication output among doctoral graduates. It is interesting to note that there are a variety of research areas among the top 10 popular journals, indicating a healthy spread of publication and knowledge creation among research areas. Not on this list is the faculty of Economic and Management Science, which interestingly, also has the lowest output of the reported publication output per capita (0.52), according to Stellenbosch University (2016). The faculty of Military Science's publication output was not ready for reporting purposes, neither does it appear on the list of top 10 journals.

Table 4.3: Publication output of doctoral graduates at Stellenbosch University (from 2010-2015)

Publication output Summary	**Number**
Number of doctoral graduates who have published at least one article	89
Total number of Journals	229
Number of articles in peer reviewed journals	290
Average publications per doctoral graduate	3.258426966

Table 3.4: Top 10 Journals of publication by doctoral graduates at Stellenbosch University (from 2010-2015)

Top 10 Journals	**Research Area**	**Number of articles published by doctoral graduates**
Journal of Bacteriology	Medicine and Health Sciences	9
The South African Institution Of Civil Engineering Journal	Engineering	8
Macromolecules	Science	5
IEEE Transactions on Magnetics	Engineering	4
Journal of Agricultural and food chemistry	Agrisciences	3
LitNet	Arts and Social Sciences	3
South African Journal Bioethics and Law	Law	3
South African Journal of Higher Education	Education	3
BMC Musculoskeletal Health	Medicine and Health	3
Chemical Engineering Science	Engineering	3

Knowledge creation in the form of publication is not only a local, regional or even national endeavour, as it spreads across national borders and has soared in recent times due to globalisation, policy development and the age of information and technological communication. Therefore, as illustrated by Figure 3.14, doctoral graduates have published in journals located in the United States of America (USA), the United Kingdom (UK) and the Netherlands. South Africa shares fourth place with Germany in terms of journal publications. This figure could be explained by the fact that researchers are typically encouraged to publish in journals with high impact factors, of which the most are indeed in the countries listed in Figure 3.14 (Cloete, Mouton & Sheppard 2010). On the contrary, for purposes of knowledge sharing and information brokerage, one might argue that regional innovation requires access to this information. Journal subscription fees are quite steep and might limit the audience beyond the research or higher education community. Furthermore, predatory publishers / journals have

taken advantage of academic entrepreneurship and have created false journals, which have costed the government millions of Rands in subsidies (Mouton & Valentine 2016).

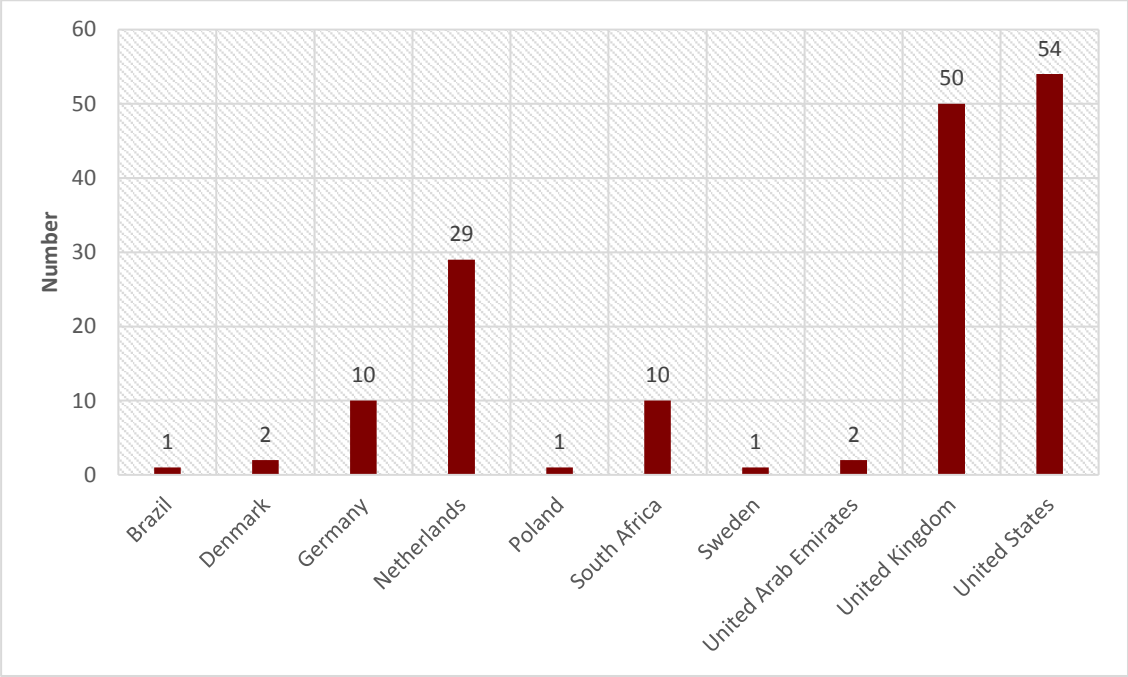

Figure 3.14: Countries of mostly frequently published journals by doctoral graduates at Stellenbosch University (from 2010-2015)

Innovation outputs allow doctoral graduates to contribute to the national system of innovation (Pedersen 2014), however, it should be noted that the creation of innovation output does not translate directly into regional innovation (Capello, Olenchicka & Gorzelak 2013; Karodia, Soni & Soni 2016). Survey results in Table 3.5, show that doctoral graduates are starting to take their ideas to the market place. Although the number of patents and patent registrations are low, one should consider the fact that nationally, Stellenbosch University has the highest number of patents and patent registrations for any entity/organisation (SASOL [9] is second). In fact, 282 patents were filed from 2000-2017 Furthermore, for the same period, 23 spin-off companies were created (Stellenbosch University 2017).

Table 3.5: Innovation products by doctoral graduates at Stellenbosch University (from 2010-2015)

Innovation outputs	**Number**

[9] Sasol is a South African chemicals and energy company

Patents	4
Patent registration	3
Trademarks	0
Companies	4

The transferability of skills obtained during doctoral studies is crucial for regional innovation, especially in terms of horizontal mobility of doctoral graduates (Pedersen 2014). Survey results in Table 3.5 show that 66% of doctoral graduates are working in fields that are directly related to their doctoral dissertation research theme. Such results highlight to two important issues: the (a) transferrable skills[10] that doctoral graduates develop during their doctoral studies mean that 44% of doctoral graduates are able to find employment in other sectors not directly related to their research theme and; (b) doctoral graduates are able to specialise in their respective fields and become experts, knowledge creators and potential innovators (Pedersen 2014). Thus, regional innovation depends on the degree to which the private sector (as the market place) can attract doctoral graduates with transferrable skills in an attempt to increase the uptake of innovative ideas and products (Capello, Olenchicka & Gorzelak 2013).

Table 3.6: Survey response to "is your current occupation related to your doctoral research theme/area"

Is your current occupation related to your doctoral research theme/area?	**Count**	**Percent**
Yes	55 (n=83)	66%
No	28 (n=83)	34%

Movement of doctoral graduates between the public sector (universities, research councils, etc.) and the private sector (industries, corporations, businesses, etc.) remains pivotal in transferring knowledge and innovation to the market (Capello, Olenchicka & Gorzelak 2013; Karodia, Soni & Soni 2014). Figure 3.15 shows that 49% of graduates are very likely or likely to start a new occupation from their current job (n=83), however, no clear deduction can be made from this since feedback is spread evenly between those who would likely start a new occupation and

[10] Transferrable skills refer to knowing and presenting complex knowledge, writing skills, time management, people management, project management, ethical training, etc. (ASSAf 2010)

those who would not. Figure 3.16 shows a similar pattern when doctoral graduates were asked if they would start a new occupation directly related to their doctoral research theme/area. 48% would be likely to very likely to start a new occupation. This trend shows that although doctoral graduates are split on whether they would start a new occupation or not, they are also split on whether that job would be more aligned to their doctoral degree research theme/area. On the other hand, one may deduce that just less than 50% of doctoral graduates would indeed be on the job market, which would be a potential supply of high-level skills for the private sector.

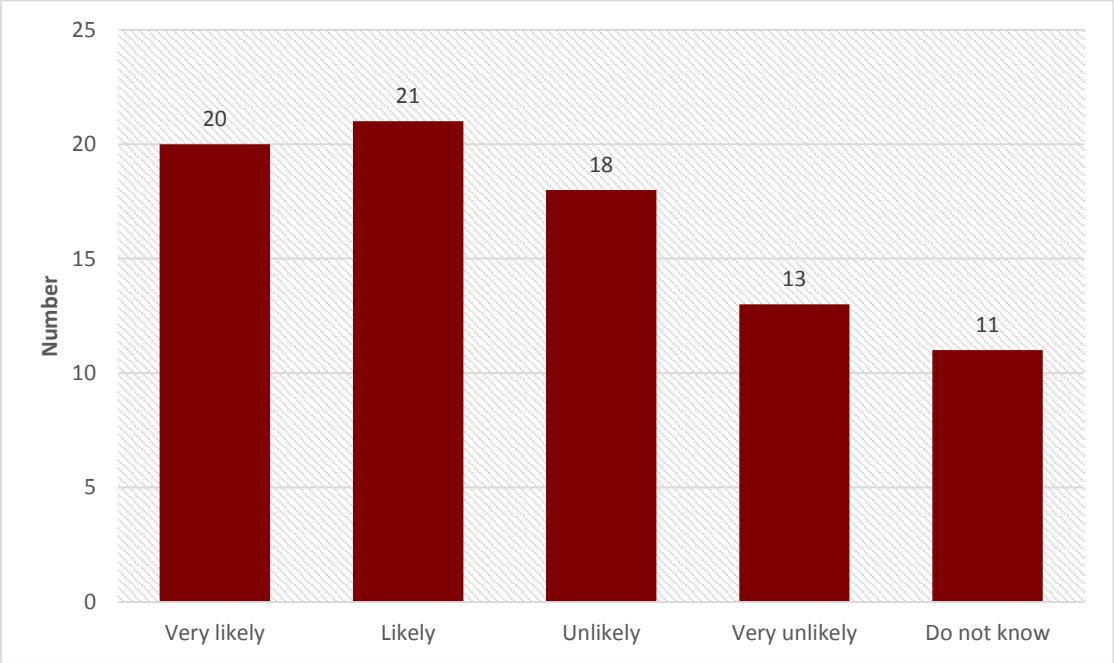

Figure 3.15: Survey response: How likely are you to start a new occupation?

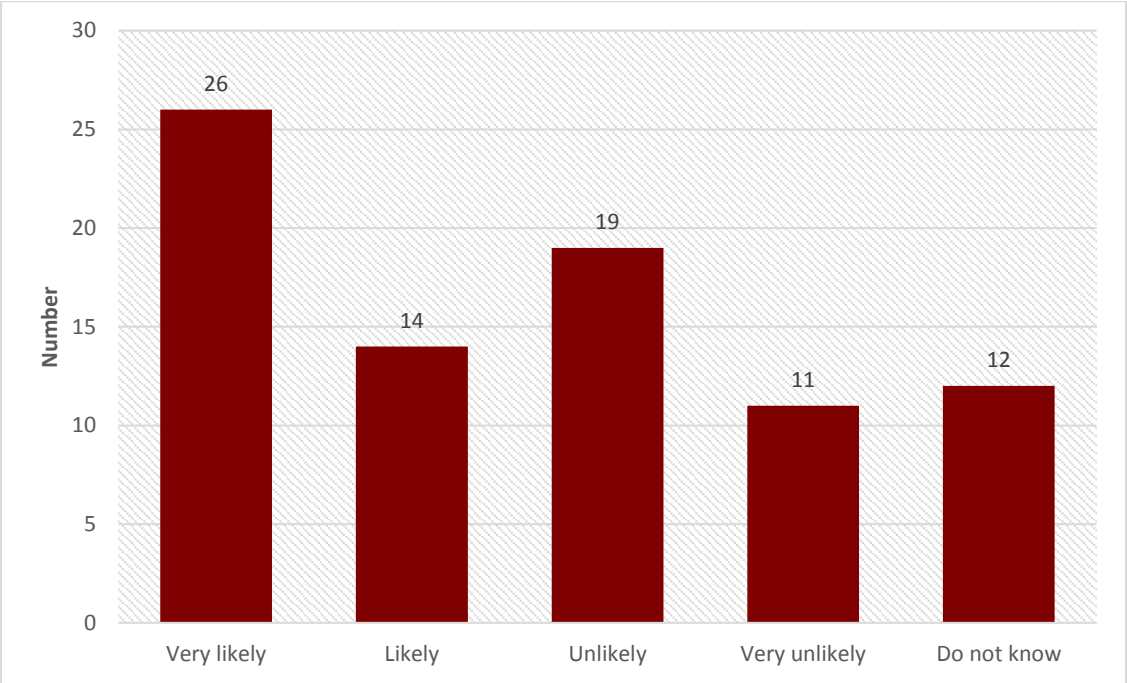

Figure 3.16: Survey response: How likely are you to start a new occupation directly related to your doctoral research theme studied at Stellenbosch University?

3.2.2 Perceptions of doctoral graduates on their own careers as knowledge creators and innovators

This section unpacks some of the perceptions doctoral graduates have regarding potential enablers and constraints in their current occupations, which may affect their ability to create knowledge and innovate. The section also unpacks doctoral graduates' inherent perceptions on their role as knowledge creators and innovators.

Understanding how graduates perceive their role in creating new knowledge and stimulating regional innovation is crucial. Survey results, in Figure 3.17, show that doctoral graduates have a number of aspects which they enjoy about their current job. Graduates indicated that they enjoy the flexibility (24%) that their current jobs offer; one respondent explained, "*It gives me almost complete freedom to do research in the directions that I enjoy. It allows me to combine in depth scientific knowledge with the creative process to design and build molecules with specific functionality"*. In addition, both teaching and the ability to conduct research was also rated high (20%, respectively) (n=80). One respondent elaborated, *"My contact with students and the teaching and learning that takes place. I am very grateful that I can contribute to the growth of my students. I love it to add value to their lives!"*

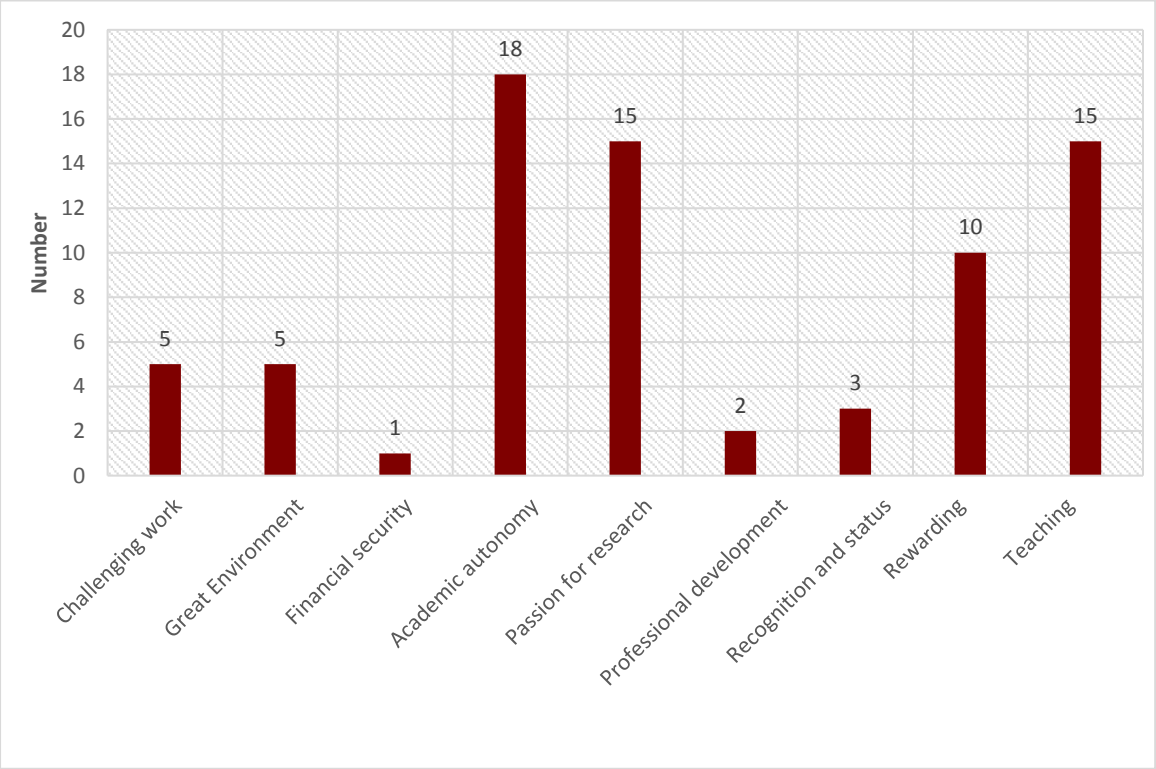

Figure 3.17: Survey response to "most enjoyable aspects of current job"

Knowledge creation and regional innovation are outcomes of the higher education sector (Cloete, Mouton & Sheppard 2015; Pedersen 2014). The aspects that doctoral graduates enjoy about their current job provide enablers for doctoral graduates to facilitate the creation of knowledge and promotion of innovation. Similarly, aspects of the current job that doctoral graduates find least enjoyable provide insight into the constraints in knowledge creation and regional innovation. When asked about the aspects of their current job (Figure 3.18) which they least enjoy, respondents indicated that their jobs are demanding (22%) (n=74). One survey respondent explained, *"Too many responsibilities result in too much multi-tasking, which lowers efficiency and productivity, as well as increases stress and anxiety. No time for in-depth research that I can do myself; most research is delegated to student[s]".* In addition to the multitude of demands on doctoral graduates as highly skilled individuals, they feel that they don't really enjoy job security due to uncertainty in the higher education sector (17%). A respondent indicated, "*Not sure about promotions as I do not want to move away from Stellenbosch and with the Fees must Fall-campaign there seems to be no money for promotions".* This response highlights the impact of lack of funding has had on researchers at Stellenbosch University. The recent #FeesMustFall student movement is calling for no fees for tertiary studies, which if successful, could change the higher education sector permanently.

Government funding is limited, investment scarce and the effects of no fees are yet to be fully unpacked (Cloete, Mouton & Sheppard 2015). This unclear future creates confusion and uncertainty among academics and researchers around future job prospects.

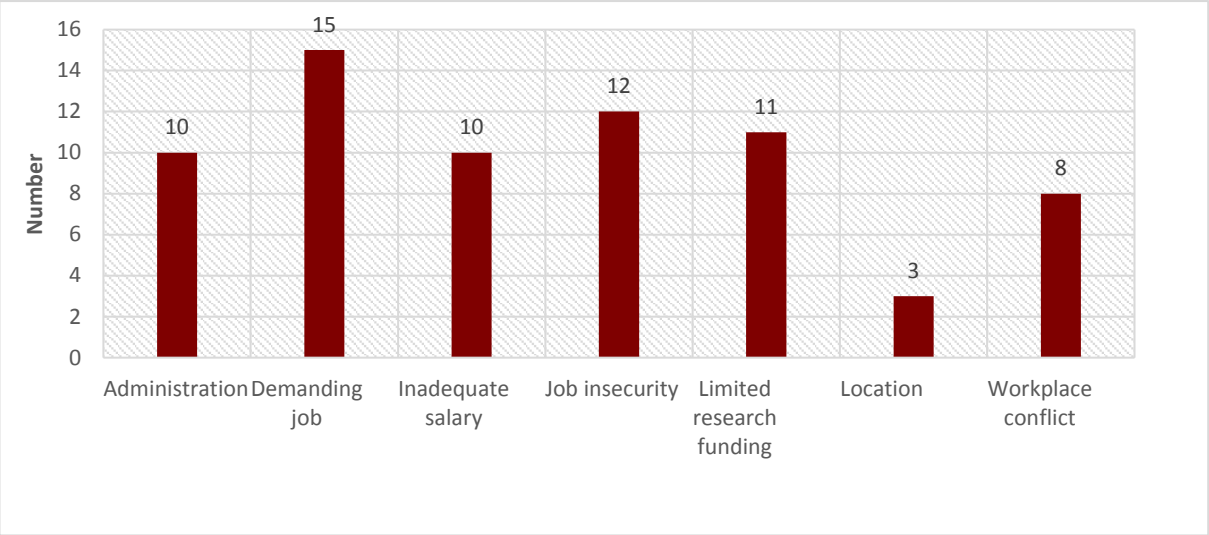

Figure 3.18: Survey response to "least enjoyable aspects of current occupation"

In terms of doctoral students' reflections on their role in knowledge creation, the vast majority of responses focused on adding to existing knowledge (93%) through publications and conference presentations. South Africa's higher education sector is a 'medium' knowledge producer (Cloete, Mouton & Sheppard 2015). In addition, 25% of the total income for the university is generated from research-related activities (Stellenbosch University 2016). Figure 3.19 illustrates that doctoral graduates consider themselves as key to knowledge creation (93%) (n=60). Such a high percentage shows that doctoral graduates see themselves as key role-players in the advancement of knowledge creation, which is required for South Africa to become more competitive in the global knowledge society.

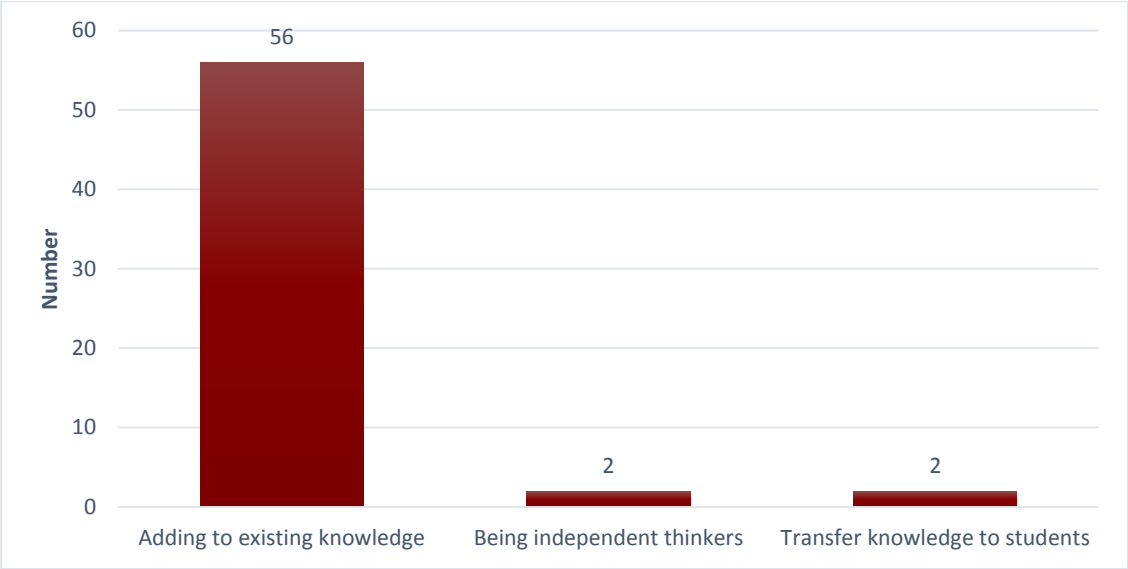

Figure 3.19: Perception of doctoral graduates regarding their role in knowledge creation

CHAPTER 4: CONCLUSIONS AND POLICY IMPLICATIONS

The study highlighted a number of pertinent findings around a) doctoral profiling with regard to demographic, educational and socio-economic characteristics and b) knowledge and innovation elements. Demographic characteristics in terms of race, gender, age, nationality, location and home language provided some insights into the composition of graduates at Stellenbosch University from 2010-2015. A total percentage of 60% of graduates were white and 60% were male. Demographical imbalances between White graduates and BCI graduates at Stellenbosch University persist against a backdrop of the demographic composition of the Western Cape population, but there have been notable increases in Black graduates (Black South African and other African graduates) at Stellenbosch University during the study period. Graduates were on average 38 years old with the exception of white females who were on average 35 years old. This means it takes approximately 20 years for a high school matriculate to graduate with a doctoral qualification. South African nationals make up the bulk of doctoral graduates during this period (70%) which is higher than the national trend, where non-South African graduates account for at least 60% of all graduates. The majority of all graduates are English speakers, followed by Afrikaans speakers – both predominant languages in the Western Cape (Statistics SA 2012). Graduates originate from various geographical areas in South Africa and abroad, yet overall, most graduates are from the Western Cape Province, which presents a positive relationship between the location of the University and the proximity of students; this, in turn, signals some benefits for regional economic development since most graduates indicated that they are still actively working in this region. English is the most common home language followed by Afrikaans. A total percentage of 90% of Afrikaans speakers are white graduates.

Educational characteristics regarding faculty distributions, research areas/themes, degree structure, and educational history as well as underlying motivations for choosing Stellenbosch University, in turn, provided insight into doctoral graduates' research direction and educational history. Science (24) and Arts and Social Sciences (19%) represent the top 2 faculties in terms of graduate outputs. Significantly, 9 of the top 10 research areas / fields were SET fields. This aligns strongly with the National Development Plan's call for more SET doctoral graduates (NPC 2012). A total percentage of 59% of all graduates were full-time registered students, which results in earlier graduations as opposed to part-time students. Participants also indicated that they take into considerations the expertise of staff, connections with supervisors as well as

the reputation and location of the institution into consideration when choosing their ideal university.

Economic characteristics regarding doctoral graduate occupations, income levels, perceptions around income, funding sources and household size provide insight into the economic realities faced by this elite group of skilled professionals. The majority of survey respondents indicated that their current job is related to higher education. They earn between R307601-R1228800 per annum (63%) from junior lecturer to distinguished professors (based on Stellenbosch University salary scales). These salaries are relatively high considering the high levels of poverty in South African and most respondents (83%) indicated that they are either living comfortably or coping on present income. The majority of survey respondents (80%) have household sizes either of 2-4 persons, meaning they are married, with children or living with family. In addition, Stellenbosch University institutional funding, National Research Foundation and own-funding were the highest ranked funding sources for doctoral graduates during their studies.

Knowledge creation appears to be spread across various disciplines and doctoral graduates prefer publishing in journals from the US, the UK and the Netherlands. Journals from these countries have much higher impact factors than those from third world countries. Furthermore, graduates produced 4 patents, 3 patent-registrations and 4 spinoff companies which strongly suggests a movement towards regional innovation. Graduates also indicated that they were more likely to start a new job but they were split on whether or not this job would be directly linked to their doctoral studies.

The overarching purpose of this study was to understand the role doctoral graduates, at Stellenbosch University, play in terms of knowledge creation and regional innovation; to achieve this purpose, it became necessary to unpack the evolution of doctoral education, its models and function to society as well as the factors affecting doctoral education success, as captured in the literature review for this study. In addition, unpacking knowledge creation and regional innovation assisted with the contextualisation for this study. A ‘brain drain’ is affecting South Africa at an alarming rate and this presents some challenges for improving the supply of critical skills (particularly in the SET fields). At the same time, a lack of evidence on the value placed by firms on doctoral graduates, a lack of clear understanding by governmental agencies as to the role of doctoral graduates in society, as well as problems associated with funding, infrastructure, capacity and job security, impacts on expansionary approaches to doctoral

education in South Africa. Understanding the role of doctoral graduates in knowledge creation and regional innovation offers insight into the potential of any region to harness these skills, knowledge and expertise to serve as catalysts for regional economic development and the betterment of society, in general.

4.3 POLICY IMPLICATIONS

- Enhance policies should set equity targets to improve the throughput of Black students at doctoral level and at the same time, increase the capacity of the system to take on board more quality doctoral students. In other words, equity should not lead to a decrease in the number of White graduates to accommodate more Black graduates; rather increasing capacity to increase the number of graduates for all demographic groupings should be the goal.
- Determine the threshold for SET graduates. The NDP 2030 only speaks to a target of 5000 graduates with most graduates from SET (science, engineering and technology) fields as the target. The plan falls short by not proposing funding or capacity to reach this target.
- Optimise best practice sharing. Considering the fact that Stellenbosch University is a leading doctoral producer in South Africa, best practices should be shared to increase the number of doctoral graduates at other institutions across South Africa.
- Evaluate and improve current incentives to innovate. Innovation should be incentivised largely, in order to gain more benefits from existing knowledge for firms, but also for societal developmental benefits. Technology transfer offices should be supported through governmental grants to invest in start-up companies and support the transfer of ideas into technological innovation not only locally but also for regional and national gain.
- Implement a community of practice programme under the auspices of the Universities South Africa, to identify areas for improvement (e.g. dual-degree programmes) to further lead to expansion and avoid issues emanating from a lack of coordination (e.g. over-duplication of programmes, infrastructure, etc.).

4.1. LIMITATIONS OF THE STUDY

Doctoral education is closely linked with knowledge creation and innovation (regional innovation) since it is the apex product of the academic enterprise. This study did not measure the impact of doctoral graduates regarding the creation of knowledge or regional innovation. It

merely attempted to understand the role graduates are playing today in terms of shaping society through the creation of knowledge and contributing to innovation and competitiveness. The low response rate for the survey increases the potential for non-response bias and an attempt was made through multiple reminders to increase the response rate, however, responses remained quite low, possibly because there were no incentives for participating in the online survey. The findings of this study can only be considered trends of doctoral graduates at Stellenbosch University from 2010-2015.

4.2. RECOMMENDATIONS FOR FUTURE RESEARCH

The study only begins to unpack the role doctoral graduates are fulfilling in knowledge creation and regional innovation. Future research could focus more closely on the impact of graduate outputs, and a longitudinal study on the impact of doctoral graduates in higher education, industries and society would be important. Such a study would be a vital contribution to policy-makers who are tasked with the design and implementation of legislation aimed at expanding doctoral graduates.

Word count: 17 304

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APPENDIX A

STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

PROJECT TITLE: ***Profiling Doctoral Graduates at Stellenbosch University between 2010 and 2015: Understanding their role in Knowledge Creation and Application***

REFERENCE NUMBER: pending
RESEARCHER: Mr. Nugent Duncan Dain Lewis
ADDRESS: The Centre for Regional Innovation and Urban Innovation and Statistical Exploration (CRUISE), Department of Geography and Environmental Studies, Chamber of Min Corner of Merriman and Ryneveld Streets, Stellenbosch.
CONTACT NUMBER: 021 808 9017

Dear Alumni

My name is Nugent Lewis and I am a MPhil Candidate in Urban and Regional Science at CRUISE at the Department of Geography and Environmental Studies at Stellenbosch Univers like to invite you to participate in a research project entitled, "Profiling Doctoral graduates at Stellenbosch University between 2010 and 2015: Understanding their role in knowledge c regional innovation". The aims of the study are to identify the educational, socio-economic and socio-demographic characteristics of Doctoral graduates, and to understand their im stimulating the creation of knowledge, as part of the knowledge economy, through its beneficial impacts on regional innovation systems.

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any a study. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Humanities Research Ethics Committee (HREC) at Stellenbosch University** and will be conducted according to accepted and applicable international ethical guidelines and principles.

This questionnaire will take about 20minutes to complete. The information received from participants will remain confidential and anonymous and no personal information will be r The data will be anonymised through summarising it in cross-tabulations and average percentages. The data will be stored on a password protected computer. Participation in this que completely voluntary and participation can be withdrawn at any time. A copy of the final research report can also be made available upon request.

If you have any questions or concerns about the research, please feel free to contact me at nugentl@sun.ac.za or my supervisor Ms Lorene Willemse at lorenew@sun.ac.za or 021 808 9

RIGHTS OF RESEARCH PARTICIPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights o because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché (mfouche@sun.ac.za; 021 808-4 Division for Research Development.
You have the right to receive a copy of the information and Consent form.

Yours sincerely

Nugent Lewis
Principal Investigator

*I have read and understand the information provided in the "consent to participate in the research"

- Yes

*I understand that my participation is entirely voluntary and that I am allowed to withdraw at any time

- Yes

*I understand that the information will remain confidential and anonymous and that no personal information will be made available. I also have right to request a version of the final mini-thesis at any point

- Yes

APPENDIX B

Journal Names	Brazil	Denmark	Germany	Japan	Netherlands	Poland	South Africa	Sweden	United Arab Emirates	United Kingdom	United States	Grand Total
Acta Physiologica										94		94
Advances in Clinical and Experimental Medicine						16						16
African Identities											6	6
African Journal of AIDS Research										22		22
African Journal of Marine Science											42	42
Animal Feed Science and Technology					92							92
Antimicrobial Agents and Chemotherapy											218	218
Applied and Environmental Microbiology											270	270
Applied Energy										125		125
Applied Financial Economics										42		42
Applied Microbiology and Biotechnology			358									358
Aquaculture					136							136
Aquaculture International					43							43
Aquaculture Research										67		67
Archives of Virology			95									95
Austral Ecology										71		71
Behavioural Brain Research					144							144
Biochemical Pharmacology					171							171
BMC genomics										123		123
BMC medical genetics										58		58

BMC Research Notes										47		47
Carbohydrate polymers										145		145
Cardiovascular journal of africa							24					24
Cell biochemistry and function											50	50
Chemometrics and Intelligent Laboratory Systems					99							99
Circulation journal				83								83
Clinical Microbiology and Infection										114		114
Control Engineering Practice										93		93
Current Nanoscience									33			33
Current Pharmacogenomics and Personalized Medicine									16			16
CyTA - Journal of Food										13		13
Cytotechnology					47							47
Development										28		28
Development Southern Africa										62		62
Disability and Rehabilitation										88		88
Diversity and Distributions										94		94
Education as Change										8		8
Education, Citizenship and Social Justice											14	14
eLife										61		61
European Journal of Plant Pathology					156							156
Experimental Biology and Medicine											128	128
FEMS Microbiology Letters										126		126

Food and Bioprocess Technology											54	54
Food Chemistry					193							193
Fungal Biology					85							85
Gene					157							157
Geography										20		20
Historia	6											6
Human mutation											135	135
IEEE Transactions on Magnetics											109	109
IEEJ Transactions on Electrical and Electronic Engineering											20	20
International Journal of Cardiology					98							98
International Journal of Disability, Development and Education										27		27
International Journal of Food Science and Technology										73		73
International Transactions in Operational Research		16										16
Journal of Agricultural and food chemistry											235	235
Journal of Applied Business Research											13	13
Journal of Bacteriology											208	208
Journal of Cereal Science											91	91
Journal of Chemical Technology and Biotechnology											94	94
Journal of Evaluation in Clinical Practice										58		58
Journal of Exercise Physiology Online											19	19

Journal of Experimental Botany										183		183
Journal of Food Science											117	117
Journal of Human Development and Capabilities											14	14
Journal of Literary Studies										4		4
Journal of negative results in biomedicine										18		18
Journal of Organic Chemistry											197	197
Journal of Planning Education and Research											54	54
Journal of Shellfish Research											52	52
Life Sciences					138							138
Life Writing										5		5
Literator							1					1
Macromolecular Rapid Communications										128		128
Macromolecules											269	269
Manual Therapy											70	70
Marine Biotechnology			64									64
Mental Health and Physical Activity					21							21
Metabolomics			54									54
Microbiology										304		304
Microelectronic Engineering					82							82
Minerals Engineering					75							75
Molecular Microbiology										215		215
Mycological Progress			24									24
Nanotechnology										159		159

New Journal of Physics										119		119
New Microbes and New Infections					11							11
New Phytologist										184		184
Perspectives in Education							14					14
Pharmacogenetics and genomics											129	129
Pharmacogenomics										77		77
Physica Scripta								63				63
Physical Review Letters											504	504
Plant Cell											289	289
Plant Journal										219		219
Plant Physiology											252	252
Planta Medica			97									97
Plasmid											50	50
Plos One											436	436
Policy Futures in Education										9		9
Postharvest Biology and Technology					109							109
Probabilistic Engineering Mechanics					58							58
Progress in Neuro-Psychopharmacology and Biological Psychiatry					104							104
Prosthetics and Orthotics International		42										42
Public Health Ethics										15		15
Public Health Nutrition										111		111
Qualitative Health Research											83	83
Qualitative Research in Psychology										20		20
Smart materials and Structures										117		117

Social Indicators Research					76							76
South African Historical Journal										10		10
South African Journal of Business Management							20					20
South African Journal of Plant and Soil										14		14
South African Journal of Psychology							27					27
Structural Safety					69							69
Toxicology					130							130
Transport in Porous Media					65							65
Tuberculosis											75	75
Tydskrif vir Letterkunde							6					6
Virus Research					97							97
War & Society										4		4
Water Resources Research											158	158
Grand Total	**6**	**58**	**692**	**83**	**2456**	**16**	**92**	**63**	**49**	**3574**	**4455**	**11544**